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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 50 DECEMBER, 1943 No. 6

ANNULAR SHADOWS OF UNUSUAL TYPE ASSOCIATED WITH ACUTE PULMONARY INFECTION*

By L. R. SANTE, M.D.
ST. LOUIS, MISSOURI
and
C. E. HUFFORD, M.D.
TOLEDO, OHIO

ALMOST two decades have passed since the controversy over the cause of various types of annular shadows was apparently terminated by the almost simultaneous publication by Arnell[3] and Doub[4] of cases in which autopsy findings proved the existence of emphysematous pleural blebs and bullae as the cause of certain thin-walled, rounded shadows in the lung field. Although this was predicted by Maragliano[12] in 1912 its proof was not forthcoming until 1927.

The early discussion embraced practically every rounded shadow found in the chest.[1,2,5,6,8,9,11,13,15,18,19] Subsequent years have established beyond a doubt the occurrence of annular shadows in the chest from many causes: cavities in the lung, from tuberculosis, pyogenic infection, or as a result of necrosis in malignant tumors; emphysematous pleural blebs and bullae; localized pneumothoraces, bronchiectatic dilatation of the bronchi; congenital and acquired pneumatoceles, either single of the balloon cyst type or multiple of the honeycomb variety. Logical explanations have been made, in most instances, for the manner in which these conditions arise, although the cause of their development has not been clearly understood in some cases. One would think that the chapter on annular shadows had been completed and ended.

In recent years, however, a number of cases have been observed, all similar roentgenologically, which do not seem to conform to the types ordinarily encountered. All had their onset clinically with evidence of infection—sore throat, mastoiditis, arthritis, etc., rapidly developing systemic infection with chills or chilly sensations, followed by high fever and leukocytosis. Blood cultures were positive showing streptococci, either hemolytic or non-hemolytic or *Staphylococcus aureus*, or some other type of pyogenic organisms.

Roentgenographic examination at the beginning usually gave no indication of what was to follow. Within a few days after the onset of acute symptoms, multiple nodules, usually rounded, appeared simultaneously throughout both lung fields. These varied in size from 0.5 to 6 cm. in diameter and at first usually appeared solid. Central rare-

* From the Departments of Radiology of St. Louis University Medical School, St. Louis City Hospital and St. Vincent's Hospital, Toledo, Ohio. Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.

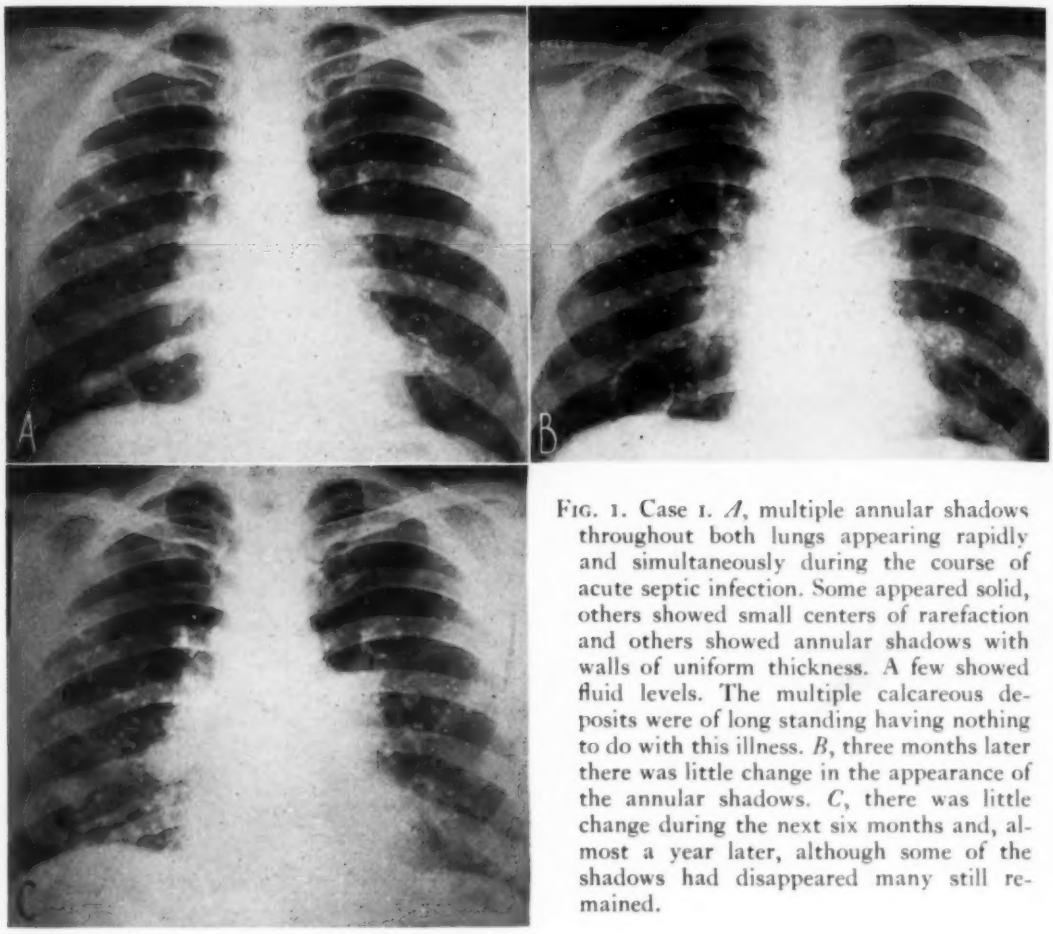

FIG. 1. Case 1. *A*, multiple annular shadows throughout both lungs appearing rapidly and simultaneously during the course of acute septic infection. Some appeared solid, others showed small centers of rarefaction and others showed annular shadows with walls of uniform thickness. A few showed fluid levels. The multiple calcareous deposits were of long standing having nothing to do with this illness. *B*, three months later there was little change in the appearance of the annular shadows. *C*, there was little change during the next six months and, almost a year later, although some of the shadows had disappeared many still remained.

faction rapidly converted them into annular shadows of unusual variety, having walls 2 to 5 cm. in thickness. In some instances the rarefaction was not uniform, due perhaps to a failure of a portion of the nodule to break down. In others, complete destruction of the center of the nodule resulted in fluid which showed as a distinct fluid level. For the most part, however, they were filled with air, showing little infiltrative reaction in the surrounding lung tissues. None of these areas showed any change in size during respiration, and, although they undoubtedly communicated with the bronchi, none could be filled by intratracheal injection of lipiodol. Body section roentgenography showed them all to be within the lung, near the periphery but not at the pleural surface. In one instance a moderate pleural effusion was present before the annular shadows appeared.

In most cases they appeared suddenly and simultaneously within a few days after the onset of the disease, remaining for several days or weeks and then gradually disappeared. In one instance defervescence was prompt and resolution rapid after sulfathiazole; in another, even after many types of sulfa drug therapy the ring-like structures persisted for over a year, and the patient continued to run a slight afternoon temperature (99.5° to 100° F.). In spite of this he was able to carry on his work. In still another some of the areas became adherent to the pleura forming localized areas of empyema which had to be drained by operative procedure. Only one succumbed to the disease.

CASE REPORTS

Case I (No. 6627). C. C., white male, aged thirty-four. Entered St. Louis City Hospital, June 6, 1941, with chief complaint of sore throat, multiple joint pains and general lymphadenopathy. He had been subject to arthritic pains for years; six days before entrance he had a severe sore throat which caused exacerbation of his arthritic pains and fever. He was in bed for four days during which time he lost 13 pounds. Physical examination disclosed multiple hot swollen joints, general adenopathy and splenic enlargement, but was otherwise negative. Physical examination of the chest failed to disclose evidence of any pathological condition at this time.

Biopsy of a lymph node revealed hyperplasia only. Urinalysis negative. The white blood count ranged between 10,400 and 9,900; the red blood count was 5,200,000 and the hemoglobin determination was 14.1 grams per cent. The differential count showed a definite shift to the left with eosinophiles 1, 1, 3, 5, and 11 per cent on five different occasions. The Wassermann and Kahn and the gonorrheal fixation tests were negative. The sputum was negative on many occasions for tubercle bacilli, fungi and anaerobic bacteria, but *Streptococcus viridans* was present on three occasions; unfortunately blood cultures were not made at these times.

Roentgen examination (Fig. 1) on June 7, 10, 11, and 14, 1941, revealed multiple annular shadows throughout both lungs varying from 1 to 4 cm. in diameter. Some appeared as smooth, rounded rings with walls of uniform thickness varying from 2 to 4 mm. Others were either totally or partially solid; some showed small amounts of retained fluid. There was little if any change during this period.

Oblique roentgenograms made at this time showed these ring-like structures to be near the periphery of the lung, but not at the pleural surface. Multiple small calcareous deposits throughout the lungs were attributed to old healed childhood tuberculous infection.

The patient improved considerably under salicylate therapy, and insisted upon his discharge from the hospital on June 22, 1941.

On August 29, 1941, he was re-admitted for tonsillectomy. This was accomplished without incident. At this time the adenopathy and splenic enlargement had disappeared, but the annular shadows were still present in the chest, showing little change (Fig. 1, *B*).

Examination on October 29, 1941, revealed very little change in the shadows.

By February 19, 1942, some of the thinner walled shadows had become less distinct but those which appeared as totally solid nodules, and those showing only small rarefied foci in the center, showed little change (Fig. 1, *C*). Body section roentgenographic examination made at this time served to further substantiate the character of these structures, and showed them to be near the lung periphery but not at the pleural surface.

On February 23, 1942, the patient re-entered the hospital after a "flare-up" of the joint pains and the appearance of subcutaneous nodules on the extensor surfaces of the left forearm, left popliteal space and dorsum of the foot. Urinalysis was negative. The white blood count was 12,700, and the red blood count was 4,300,000. The Kahn test was negative. Blood cultures taken at this time were negative on three occasions. The patient's temperature ranged from 99.6° to 101.6°F. Roentgen examination still revealed the multiple annular shadows previously present; a few had disappeared, some were smaller but the majority showed little change. He insisted upon his discharge, February 28, 1942.

Subsequent examination almost one year after first examination still disclosed the annular shadows. In spite of his condition he continued to work during the interval.

Case II (No. 41-1161). E. D., white female, aged eleven. Entered St. Mary's Hospital, St. Louis, May 20, 1941, with chief complaint of sore throat and pain in the right mastoid region; temperature 105°F., respiration 38 per minute, pulse 120 per minute.

Six days before entering the hospital the patient contracted a sore throat, but this was not very severe until the day of admission. At this time the patient was seized with chills attended with high fever and pain in the right mastoid. A chronic otitis media of two years' duration had been reactivated by the infection.

Physical examination at this time showed nothing of significance other than sore throat and profuse purulent discharge from the right ear. The lungs showed no evidence of involvement.

Blood culture at this time (May 29, 1941) showed *Streptococcus haemolyticus*, "gram positive cocci in chains." No pneumococci could be found but gram positive cocci of the same type

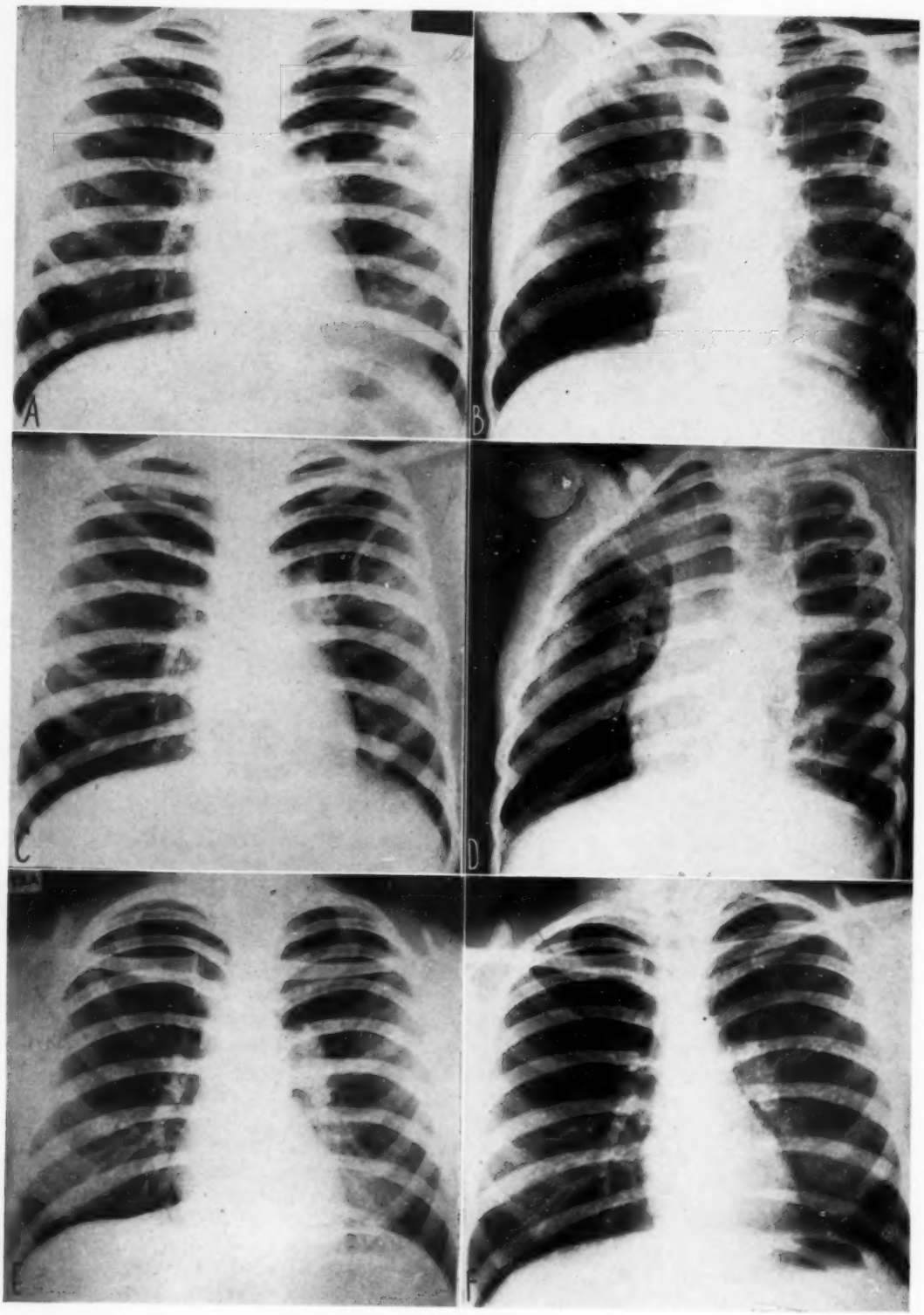

FIG. 2. Case II. *A* and *B*. Two irregular areas of infiltration appearing in the lung field three weeks following *Streptococcus haemolyticus* septicemia. Attention was called to the chest by pain. There had been no previ-

as those seen in blood cultures were found in large numbers in the sputum. Sulfanilamide therapy was instituted, followed by sulfathiazole, and within two days the blood cultures became negative; all subsequent cultures likewise failed to reveal organisms.

The patient improved on sulfathiazole therapy with reduction of fever to about 100.4°.

On May 25, 1941, she first complained of pain in the left apex; this was not very severe and did not cause much distress.

The infectious blood picture likewise improved during this period: May 20, 1941, the white blood count was 20,100; 2 juvenile cells, 10 stab cells; 78 segmented cells.

May 22, 1941, the white blood count was 15,000; 2 juvenile cells; 13 stab cells; 64 segmented cells.

May 29, 1941, the white blood count was 9,750; 0 juvenile cells; 2 stab cells; 64 segmented cells.

Roentgen examination (Fig. 2, *A*) on June 10, 1941, revealed two irregular areas of increased density, one in the left upper lung field, about 3 cm. in diameter showing some evidence of central destruction and another even larger area, low down in the left cardiophrenic region which appeared solid.

The oblique roentgenogram (Fig. 2, *B*) taken on June 11, 1941, showed both of these lesions to have areas of destruction, the upper lesion showing a fluid level.

By June 16, 1941 (Fig. 2, *C* and *D*) the upper lesion had become fully 5 cm. in diameter with a uniform wall thickness and fluid level; the lower lesion had undergone considerable reduction in size.

By June 23, 1941, the upper lesion had shrunk to about 3 cm. in diameter and no longer showed a fluid level; the lower lesion had resolved considerably.

Examination on July 11 (Fig. 2, *E*) indicated that the upper lesion was still smaller and showed even less distinctly the surrounding wall. The lower lesion had become progressively smaller; it evidently never underwent destruction and liquefaction.

By July 31, the upper lesion appeared only as a thin line outlining the previous site of the lesion. The lower lesion had disappeared.

The final examination made on August 11, showed the upper lesion as an oval hair-line structure resembling what we have been used to considering as an emphysematous bleb. The site of the lower lesion could not be detected.

The patient progressed to complete clinical recovery.

Case III (No. 81515). F. N., white male, aged thirty-seven. Admitted to St. Louis City Hospital on May 27, 1939, conscious and rational, with the chief complaint of dull pain in left groin, sore throat, chills and fever.

Onset was with a dull aching pain in the left groin four days before admission to the hospital. This was followed two days later by pharyngitis. The next day he had two successive chills, lasting about fifteen minutes each, followed by fever.

On physical examination there was injection and reddening of the pharynx and enlargement of the cervical lymph nodes. Other than this the physical examination was essentially negative. There were no pathological findings in the chest. The patient was admitted with a temperature of 104.4°F., pulse rate of 114 per minute and respiratory rate of 28 per minute, blood pressure 130/84, and white blood count of 8,100.

Roentgen examination of the chest, May 29, 1939 (Fig. 3, *A*) revealed two small, rather vague areas of parenchymal infiltration in the right lung field. These were not considered as of much consequence at this examination.

On May 30, 1939, three days after admission, the patient developed abdominal cramps and had three watery stools. This diarrhea persisted for some time but never developed into a serious condition. At this time, however, the patient developed an inflammation of the right eye, iridocyclitis and pingueculae.

ous chest symptoms. On the oblique roentgenogram (*B*) the upper area was seen to be due to an annular shadow with small fluid level; the lower area, in the cardiophrenic space appeared to be solid. Case II. *C* and *D*. In less than a week the upper area had increased considerably in size, taking on a more rounded form with a uniformly thickened wall. The lower dense shadow had subsided materially. Case II. *E*, from this time on both shadows showed continual regression as the patient's clinical condition improved. *F*, the ultimate appearance of the upper shadow was a thin, hair-lined annular shadow such as we have been used to considering as an emphysematous bleb.

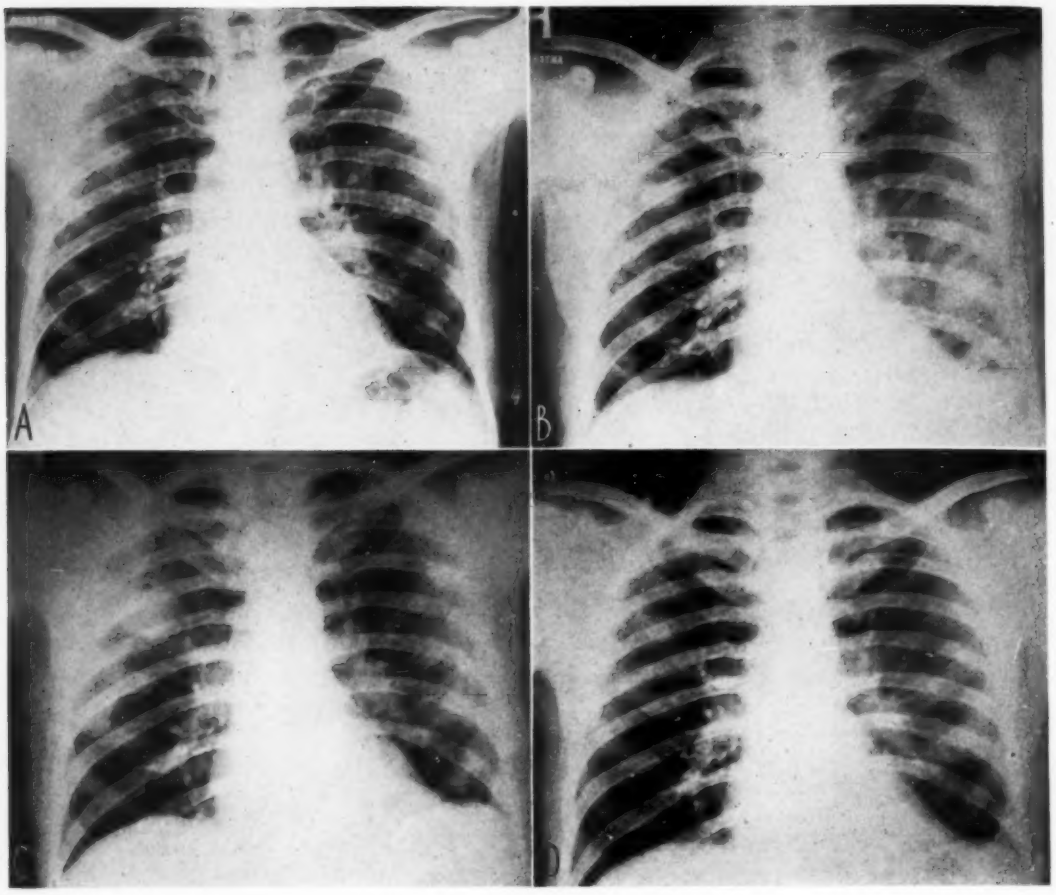

FIG. 3. Case III.

A. On May 29, 1939, six days after onset during the course of septicemia, two irregular areas of infiltration appeared in the right lung field. No great importance was attached to these at this time.

B. By June 10, 1939, the upper lesion on the right side had become annular and had enlarged to 2.5 cm. in diameter. There was partial central destruction. The lower lesion on this side showed central destruction with thick walls. A new lesion fully 6 cm. in diameter had appeared in the left lower lung field.

C. By June 26, 1939, further change had occurred. The lesion in the upper right lung field had enlarged to 4 cm. in diameter showing an eccentric area of destruction. The lesion previously present in the lower right lung field and the extremely large lesion in the lower left lung field had disappeared.

D. By July 3, 1939, all of the lesions had practically disappeared leaving only a small oval shadow 1.5 by 2 cm. in size with a fine margin in the right upper lung field resembling an emphysematous bleb.

On June 1, roentgen examination of the chest revealed that the areas of infiltration had become somewhat larger showing a more rounded appearance with central rarefaction. Numerous others had appeared.

On June 2, 1931, he developed red, swollen, somewhat tender areas on the right forearm and dorsum of the left wrist. The blood culture showed *Staphylococcus aureus;* at least seven other cultures taken throughout the course of the disease showed similar organisms. Cultures of the stools and urine were negative. The white blood count was still low, 9,750.

Staphylococcus aureus antiserum was administered at daily intervals from this point on in the course of the disease with excellent response in the general condition of the patient. Four blood transfusions were given during the course of the disease. By June 30, 1931, the blood cultures became negative. The white blood count at this time was 9,200.

The condition of the eye, however, continued

to become worse so that by June 8, 1939, panophthalmia of the left eye had resulted; enucleation was finally performed on July 6, 1939.

By June 10, roentgen examination of the chest (Fig. 3, *B*) revealed that the upper lesion on the right side had enlarged to 2.5 cm. in diameter and showed uniformly thick walls. There was partial central destruction. The lower lesion on this side showed central destruction with thick walls and another lesion fully 6 cm. in diameter had appeared in the left lower lung field.

Roentgen examination on June 26 1939, revealed further change (Fig. 3, *C*); one of the original lesions in the upper right lung field had enlarged to 4 cm. in diameter showing an eccentric area of destruction, but having a rounded uniform wall in the excavated region. The lesion previously present in the lower right lung field had disappeared. A number of other small irregular areas of infiltration had appeared in the left lung, but the large 6 cm. lesion previously present had disappeared.

By July 3, (Fig. 3, *D*) the rounded lesion in the right upper lung field had decreased in size and shape to an oval shadow about 1.5 by 2 cm. in size with a fine margin and a pointed end as if elongated by a pleural adhesion. All other lesions had practically disappeared from the lung fields.

Examination on July 14 still showed the annular shadow in the right upper lung field, apparently somewhat larger than at last examination but having a fine linear wall very similar in appearance to emphysematous blebs.

Case IV. (Patient of Dr. Wayne Johnston of Dubuque, Iowa, to whom I am indebted for the report of this case.)

J. P., white male, aged thirty-seven. Entered St. Joseph Mercy Hospital, September 25, 1941, with chief complaint of cough and fever.

Patient had been noticeably exhausted for about five weeks; tired easily and did not feel rested even after sleep. On September 16, 1941, he complained of pain in shoulder and upper chest; the pain started on the left side and then moved over to the right side. On September 18, 1941, he started coughing, and when seen on September 22 had a temperature of 103°F., severe cough, but no sputum. He was kept in bed and given sulfathiazole (2 gm., 2 gm., then 1 gm.) every four hours. There was no response to sulfathiazole comparable to the ordinary pneumococcus pneumonia; his fever persisted, ranging from 101° to 102°F., and his cough became productive. Two attempts to type the sputum were unsuccessful. There was not a great deal of prostration and no great increase in respiratory rate. There had been no loss of weight.

Past History. No serious illness. Tonsils previously removed. Appetite has been good.

Laboratory Findings. The white blood count was 20,000 on admittance (September 25, 1941); the white blood count remained at about 16,000 for the following four days. The polymorphonuclear leukocytes ranged between 80 to 90 per cent; the red blood cells were 4,000,000 and the hemoglobin 16 grams per cent. Smears from the sputum were repeatedly negative for tubercle bacilli and fungi; diplococci were present, some in long chains, which were bile insoluble. Blood culture showed no growth after forty-eight hours. The temperature during the five days ranged between 101.4° and 99.4°F. On September 25, the highest temperature was 100°F.; on September 26, it was 100°F.; on September 27, 101.2°F., on September 28, 98.6°F., and on September 29, 101.4°F. Empyema fluid which developed later was reported to contain streptococci. The patient was discharged from the hospital on September 29, 1941.

He went to the Mayo Clinic where he developed multiple areas of localized empyema.

Roentgen examination of the chest on September 29, 1941 (Fig. 4, *A*) revealed numerous rounded areas of increased density throughout both lung fields. Some of these appeared to be solid or filled with fluid, but others showed small areas of central destruction. Other examinations made at different times on the same day (Fig. 4, *B* and *C*) showed more distinctly the central rarefaction with the formation of smooth, rounded, ring-like lesions having uniformly thick walls.

He was discharged from the hospital on this date to go to the Mayo Clinic. (I am indebted to Dr. B. R. Kirklin for subsequent roentgenograms.) At the Mayo Clinic we are informed that the acute character of the disease subsided and the condition became more protracted. Localized areas of empyema developed at the site of the previous lesion.

Many of the lesions had disappeared but three areas of involvement still remained; one larger lesion on the left side in the mid-portion;

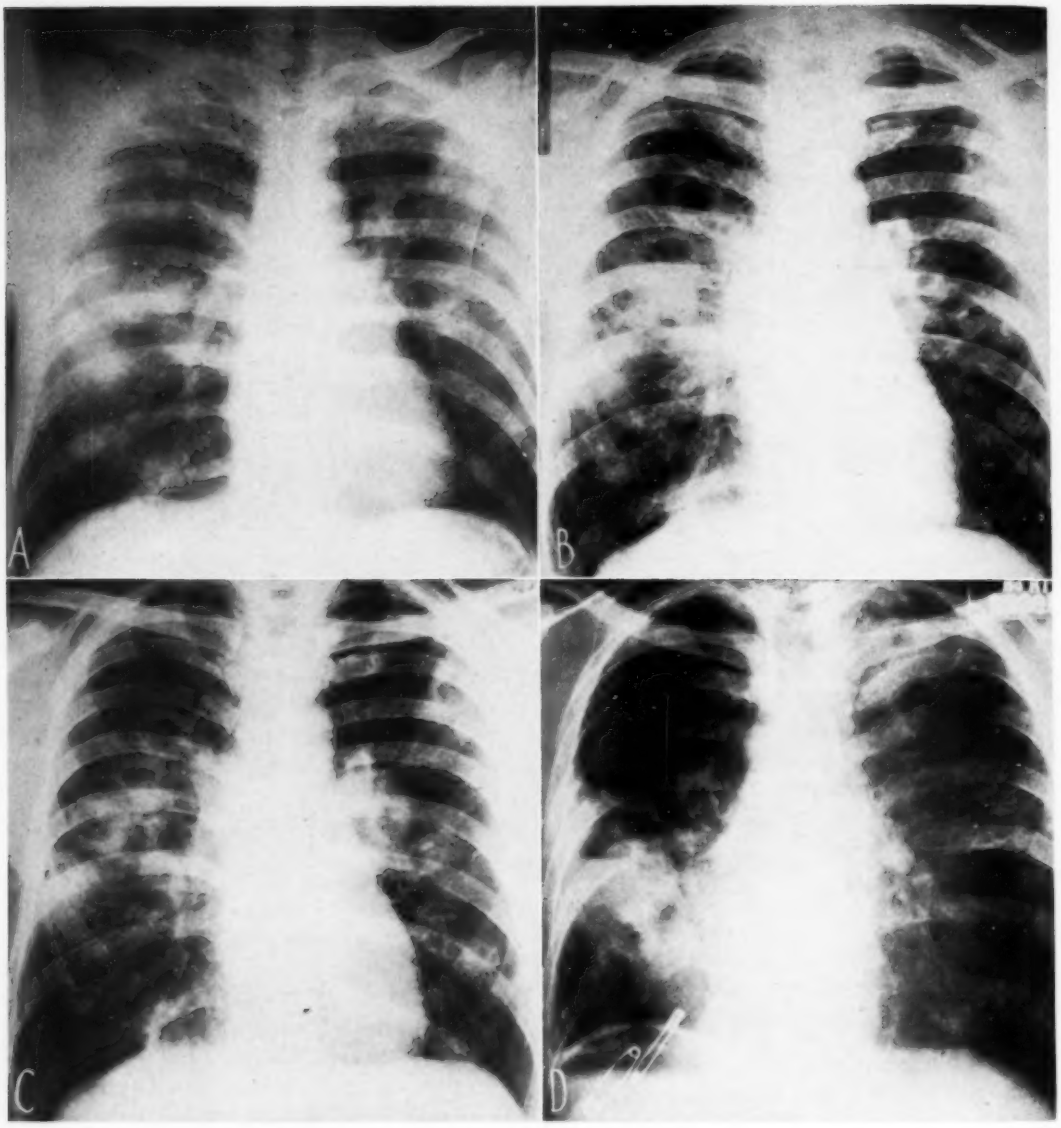

FIG. 4. Case IV (Dr. Wayne Johnston's patient).

A. Numerous rounded nodular areas appearing throughout the lungs during the course of an acute systemic streptococcus infection.

B. Further examination made later on the same day shows that some of the areas have become annular shadows. The lower lesions on the right side show excavation of the center with thick irregular walls; the upper lesions have become well defined annular shadows as if filled with fluid which had drained.

C. Development of similar lesions on the left side.

D. (Roentgenogram furnished by Dr. B. R. Kirklin.) Localized empyema produced by some of these lesions where the infection extended to pleural involvement.

two smaller areas on the right side, one in the apex and one in the mid-portion of the lung field. These gave the impression of extension to the pleural surface showing areas of localized empyema. The lesions on the right side showed progressive resolution; that on the left became even larger but still remained localized (Fig. 4, *D*). Operative drainage of this area was carried out and thick pus containing streptococci was evacuated.

The patient was returned to the former physician's care in November, 1941; areas of localized empyema had been drained and by December 4, 1941, the roentgenogram appeared normal and the patient had recovered his health.

Case v (No. 9846). E. T., white male, aged twenty, was admitted to the medical service of St. Vincent's Hospital, Toledo, Ohio, on September 3, 1941.

The onset of illness on August 29, 1941, was with sore throat and slight fever. He was seen by a doctor and treated with gargles. He was able to carry on his usual activities until August 31, 1941, with only a slight feeling of rawness in the throat. On August 31, there was sudden onset of severe cough. The cough was moderately productive and soon became blood streaked; coughing and deep inspiration caused pain over the right lower chest anteriorly. Late that evening the patient had a severe chill which awakened him and lasted twenty-five minutes. Following the chill the patient felt feverish and experienced more pain and malaise. Chills, fever and malaise persisted on the next two days; there was one chill on September 1, and two on September 2. Hemoptysis with moderately productive cough persisted from the onset of illness. No further complaints were elicited.

Past History. The patient had diphtheria in childhood, but no other illnesses were admitted. He had never left Toledo; he was employed on the production line in an automobile factory, which job he had had for two weeks. There was no history of exposure to any infectious disease.

Family History. His father was dead, cause unknown. His mother was living and well, and his twin sister was still in good health.

Physical examination revealed a well developed, well nourished young adult male who appeared to be acutely ill. His pharnyx was injected, his tongue was dry, brown and furred. Chest expansion was poor, more diminished on the right side; there was no orthopnea. A marked friction rub was present over right middle and lower lobes. Dullness was elicited over the same area and there was absence of breath sounds over the right middle and lower lobes. A few scattered fine râles were heard over the lower part of the right upper lobe but vocal resonance was absent.

The heart was enlarged to the left with the apical impulse in the sixth left interspace in the anterior axillary line. The heart beat was regular and the rate was 130 per minute. There were no adventitious sounds other than questionable apical systolic murmur. The remainder of the examination was negative.

Impression. Right middle and lower lobe pneumonia.

Laboratory Findings. The urine showed a few white and red blood cells but otherwise was normal. Examination of the sputum was negative for tubercle bacilli and pneumococci on September 3, 1941. Blood examination on the same day showed a red blood cell count of 3,860,000; white blood count 20,300; hemoglobin 75 grams per cent. The differential blood count showed polymorphonuclear leukocytes 69 per cent, juvenile cells 18 per cent, lymphocytes 12 per cent, eosinophiles 1 per cent. The icteric index on September 4 was 8.8 units; and on September 17, it was 11 units. Blood cultures on September 4, 5 and 6, 1941, were negative.

Following admission the patient was put on sulfathiazole therapy, 2 grams, repeated in four hours, and then 1 gram every four hours.

No improvement was noted until September 6, 1941, when at 10:00 P.M. the patient's temperature, which had remained at 103° to 104° F., suddenly dropped to 97° F. This was followed by a chill, and feeling of exhaustion, with a temperature rise within four hours to 104° F.

On September 8, a physical recheck showed the possibility of fluid in the right pleural cavity. The first roentgenogram was taken then. On September 9, a thoracentesis was done and 400 cc. of yellowish thin fluid was removed with some relief of symptoms. The procedure was repeated on September 11, and again on September 15 with removal of fluid. Microscopic examination of the aspirated fluid showed a few white and red blood cells but no organisms were found on direct smear or on aerobic or anaerobic cultures. No parasites or fungous growths were found.

During his stay in the hospital, the patient had a septic type of temperature, with repeated chills and attacks of orthopnea.

Medication consisted of above mentioned sulfathiazole therapy followed by:

1. Sulfapyridine instituted on September 6, when no benefit was obtained from sulfathiazole.
2. Sulfanilamide on September 14, when there was no benefit from sulfapyridine.
3. Blood transfusions of 500 cc. of whole citrated "stored" blood, September 17, 18 and 20.

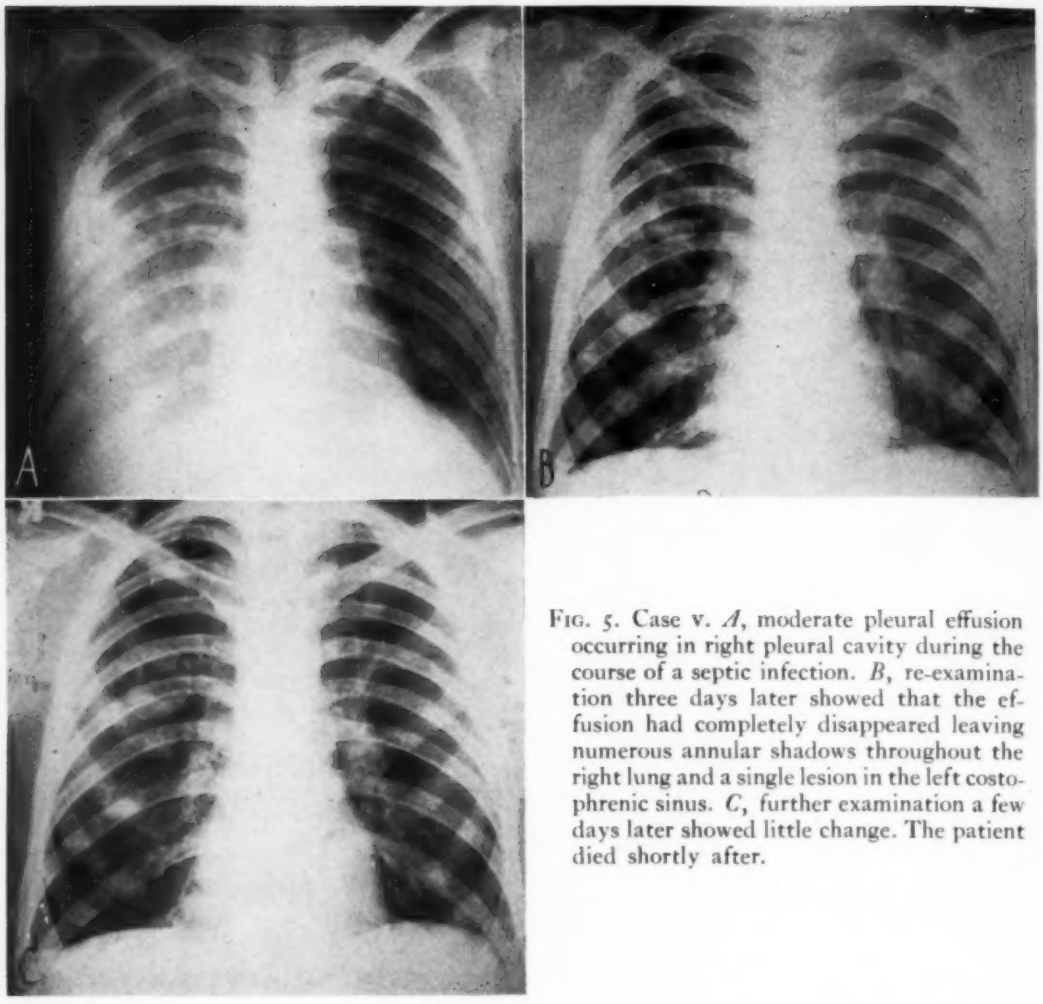

FIG. 5. Case v. *A*, moderate pleural effusion occurring in right pleural cavity during the course of a septic infection. *B*, re-examination three days later showed that the effusion had completely disappeared leaving numerous annular shadows throughout the right lung and a single lesion in the left costophrenic sinus. *C*, further examination a few days later showed little change. The patient died shortly after.

4. Nasal oxygen when orthopnea developed.
5. Sedation for periods of irrationality.

No improvement was noted and the patient died on September 22, 1941, at 7 A.M.

Roentgen examination of the chest made on September 8, 1941 (Fig. 5, *A*) showed a moderate pleural effusion in the right chest but no evidence of other pathological condition. Examination on September 11 (Fig. 5, *B*) showed that the pleural effusion had disappeared and numerous annular shadows of varying size had appeared throughout the right lung field, some having fluid levels; only one or two small lesions were seen near the costophrenic region on the left side.

On September 15, these showed little change (Fig. 5, *C*).

It will be noted that these annular shadows differ from other types more commonly encountered. They do not resemble acute pyogenic abscesses[16] in that their outer margins are rounded and smooth, their walls are of uniform thickness and they lack the surrounding infiltration common to acute lung abscess.

They differ from ordinary emphysematous pleural blebs or bullae in that they apparently originate as solid nodular structures which break down and liquefy, not as terminal vesicles which dilate from excessive intra-alveolar air pressure as a result of valvular obstruction (such as balloon air cysts) although they may ultimately

assume a similar anatomical arrangement since many of these areas undoubtedly communicate with bronchi.[10,14] Likewise, their walls are much thicker (2 to 5 mm.) than emphysematous blebs or pneumatoceles of other type such as balloon cysts or congenital cystic disease. The presence of small amounts of undrained fluid, seen as fluid levels, is also at variance with other types of pneumatoceles. A recent review of air cysts of the lung and pneumatoceles of all types failed to disclose any of this type occurring under such conditions.[17]

They do not resemble infarcts[7] *of ordinary type*, either in shape or location; they are rounded and smooth showing a capsule of uniform thickness, occurring at the periphery in any location in the lung, whereas infarcts are rather triangular in form, irregular at first, later becoming smooth if organization takes place, with margins which are most apt to occur at right angles to the pleural surfaces where the pleural planes meet. Unless infected, they become organized, forming smooth solid fibrous bodies which can be "shelled out" at autopsy; and even when they become infected they show irregular destruction, not smooth rounded ring-like structures.

Excerpts from the postmortem reports of the fatal case (Case v) by two pathologists, Dr. Thomas L. Ramsey, St. Vincent's Hospital, Toledo, Ohio, and Dr. Henry Pinkerton, St. Louis University Medical School, St. Louis, Missouri, are as follows:

Description of Lung Sections from St. Vincent's Hospital, Toledo, Ohio (concurred in by Dr. Pinkerton and Dr. Ramsey). In many areas the picture is that of pneumonic consolidation, alveoli being filled with a fresh purulent exudate. There are also several large abscesses, which partake also of the nature of infarcts. Colonies of bacteria, including staphylococci and a small bacillus, are present in the abscesses.

The blood vessels contain many thrombi, which completely occlude them, and often contain so many neutrophiles that they are regarded as septic thrombi. The pictures suggests that of staphylococcus pneumonia, which may have had some underlying virus etiology. *The abscesses are probably secondary to septic infarction of blood vessels.*

The most interesting lesion, in view of the roentgen appearance, is a cyst-like area, 1 cm. in diameter, surrounded by a band of compressed lung tissue. This may be an abscess cavity from which the contents escaped. The cyst shows a few foreign body giant cells along its lining. In order to determine the origin of this cyst, it would be necessary to study further sections.

The study, as far as it goes, suggests that the peculiar ring-shaped lesions seen in the roentgenogram are areas of septic infarction. After liquefaction has occurred, such areas may either drain into the bronchial tree and collapse or may become more or less permanently filled with fluid or air.

It will be seen from this report that one of the most significant features of the lung condition was the tendency of the infection to attack the blood vessels and perivascular tissues resulting in thrombosis. Is it not possible that thrombosis of the blood vessels may play some part in the development of these annular structures? Both the bronchial and pulmonary arteries accompany the bronchi, dividing and subdividing with each division of the bronchi as they extend toward the periphery. The bronchial artery is relatively small, it is embedded in the bronchial wall, carries arterial blood and supplies nutrition to the bronchial structures as far peripherally as the respiratory bronchiole. The pulmonary artery is much larger, it carries venous blood and although it accompanies the bronchial branches, it does not provide nourishment to the bronchi. At the terminal stage of bronchial subdivision (the respiratory bronchiole) the two circulations mix in a network of capillaries which surround the terminal alveolar structures; the nourishment of these terminal structures is derived from this capillary network.

One accepts without question the possi-

bility of occlusion of the pulmonary artery with infarction of the terminal alveolar structures; may it not be possible for thrombosis of the bronchial artery to result in infarction of the smaller terminal bronchioles? The roentgen characteristics of infarction of the lungs from emboli in the pulmonary artery have been clearly demonstrated and their pathological basis explored. Does it not seem probable that following thrombosis of the bronchial artery the bronchial structures themselves may undergo necrosis giving rise to a roentgen appearance much different from that of pulmonary artery infarction? In fact, is it not conceivable that annular shadows such as those seen in these cases may be produced under such circumstances?

REFERENCES

1. ALBRECHT, H. U. Ringschatten im Lungenröntgenbild. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1928, *38*, 367–371.
2. AMBERSON, J. B., JR. Significance of roentgenographic pleural annular shadow: present conception. *Tubercle*, 1924, *5*, 534.
3. ARNELL, S. Annular shadows in the lung caused by subpleural emphysema. *Acta radiol.*, 1927, *8*, 252–256.
4. DOUB, H. P. Subpleural emphysema as a causative factor in formation of annular shadows. AM. J. ROENTGENOL. & RAD. THERAPY, 1928, *20*, 6–12.
5. DUNHAM, K., and NORTON, V. Observations of annular shadows and cavities at Cincinnati Sanatorium. *Am. Rev. Tuberc.*, 1924, *10*, 306.
6. EVANS, W. A. Significance of annular shadows. AM. J. ROENTGENOL., 1919, *6*, 510–512.
7. HAMPTON, A. O., and CASTLEMAN, B. Correlation of postmortem chest teleroentgenograms with autopsy findings; with special reference to pulmonary embolism and infarction. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *43*, 305–326.
8. HEBERT, G. T. Annular shadows in pulmonary tuberculosis. *Tubercle*, 1923–1924, *5*, 212.
9. HONEIJ, J. A. Cavity formation and annular pleural shadows in pulmonary tuberculosis. *Arch. Int. Med.*, 1920, *25*, 63.
10. KIRKLIN, B. R. Congenital cysts of lung from the roentgenologic viewpoint. AM. J. ROENTGENOL. & RAD. THERAPY, 1936, *36*, 19–29.
11. LAURELL, H. Ein Beitrag zur Deutung der sogenannten Ringschatten in den Lungen. *Acta radiol.*, 1929, *10*, 72–116.
12. MARAGLIANO. Quoted by Vallebona.[19]
13. MØLLER, P. F., and PERMIN, G. E. Annular shadows in the roentgen picture as indications of localized pneumothorax. *Acta radiol.*, 1924, *3*, 297–306.
14. PEIRCE, C. B., and DIRKSE, P. F. Pulmonary pneumatocele (localized alveolar or lobular ectasia). *Radiology*, 1937, *28*, 651–667.
15. SAMPSON, H. L., HEISE, F. H., and BROWN, L. Study of pulmonary and pleural annular radiographic shadows. *Am. Rev. Tuberc.*, 1919, *2*, 664.
16. SANTE, L. R. Study of lung abscess by serial radiographic examination. *J. Radiol.*, 1923, *4*, 183.
17. SANTE, L. R. Cystic disease of the lung. *Radiology*, 1939, *33*, 152–165.
18. SOWERBUTTS, J. Significance of "annular shadows" in radiograms of chest. *Lancet*, 1932, *2*, 623–624.
19. VALLEBONA, A. Le formazioni pseudocavernose od anulari del polmone. *Radiol. med.*, 1928, *15*, 193–212.

DISCUSSION

DR. THOMAS L. RAMSEY, Toledo, Ohio. I do not think Dr. Sante showed the lantern slides of the case that we saw in Toledo, Ohio. I believe that our case was the only one that came to autopsy where a thorough study of the lungs could be made. Dr. Sante has slides of the sections from the lungs from our case and I am sure that he will be able to determine more of the pathogenesis in this type of case when he has the opportunity of studying the slides more carefully

I must also admit that I did not look over the slides so carefully when I first saw them as I did not do the autopsy and the case was called to my attention only because of the unusual findings from a roentgenological standpoint. These annular shadows, as presented in the first case by Dr. Sante and also in the last case, were quite numerous; that is, many shadows were present, varying in size and rather persisting as seen in several roentgenograms taken at intervals. In the first case these shadows were present for months and it leads to the opinion that in the cases that are really representative of the pathological findings in this condition they would persist for some time.

In two of the cases presented by Dr. Sante I think only two annular shadows were present; these were rather large and did not impress me as being quite similar to those seen in the case we had in Toledo, nor did they seem similar to

the cases presented by Dr. Sante where multiple annular shadows were present in the lung fields. We are more or less familiar with certain types of annular shadows as seen in cases of ordinary lung abscess or abscesses also from tuberculosis with cavitation, from formation of pneumatoceles, pleural blebs or bullae, lung cysts, etc., but we do not see many cases that present circular shadows as shown here in at least two of the cases presented.

The pathological appearance in these cases is variable in the different areas examined. Part of the picture presented is that of a rather typical bronchopneumonia or lobular pneumonia of a septic type, together with formation of abscesses in the adjacent lung tissues and sometimes complicated with pleuritis and effusion. The involvement of the terminal bronchioles, septic bronchiolitis, produces a filling of the alveolar ducts and accompanying alveoli with pus cells. This results in obliteration of the terminal branches of the bronchial arteries and septic thrombosis. There is therefore the formation of localized abscesses in the areas supplied by these vessels. The caseation of the material forms abscess cavities with fluid, as seen in some of the roentgenograms.

If you recall the slides presented in a previous paper here by Dr. Wasson, on the anatomy of the lung, you will have seen that the respiratory bronchiole entering one of the secondary lobules of the lung produces a round or ovoid shaped area and it is possible that the involvement of the terminal branches of the bronchiole arteries supplying these areas might produce, by necrosis of the tissue, such annular shadows as we see in these cases. I do not see any other better explanation. A thrombosis of the small pulmonary vessels is usually recognized as areas of hemorrhagic infarction and seen at the periphery of the lung. We do not so often see such a picture as is presented here and I believe it can be explained by thrombosis in the terminal branches of the bronchial arterioles supplying the secondary lung lobules.

In conclusion, therefore, I believe the finding of multiple, various sized annular shadows scattered throughout the lung fields, as seen in our case in Toledo and in two of the cases presented here, can be explained by thrombosis of the terminal branches of the bronchial arterioles resulting in necrosis in the areas supplied by them. These areas apparently differ from the larger, irregular shadows produced by ordinary lung abscess.

The paper has been very interesting to me and I am sure we can all profit by such a presentation.

Dr. Carleton B. Peirce, Montreal, Canada. This is a very interesting group of cases. I am sorry that we did not have the opportunity of seeing the roentgenograms of the case which came to autopsy. They might clear up a considerable amount of doubt, at least in my mind.

Dr. Ramsey has presented the pathologic features of that case, which apparently showed, as I understand, terminal bronchiolitis and also evidence of bronchiolar obstruction. On the other hand, many of the cases which Dr. Sante has shown subsequently recovered with disappearance of these annular rings or annular shadows, or a change in their size. I cannot help feeling that most of these must have been peripheral lobular pneumonia, with either a purulent bronchitis or bronchiolitis or an obstruction of the bronchus or bronchioles with involvement of the peripheral lymphatics.

Of course, these areas may go on to local destruction and formation of fluid. On the other hand, there may be produced secondary thromboses and necrotic infarcts in the peripheral tissue. The interpretation of these is extremely difficult. One tends, of course, to consider the possibility of abscess formation, particularly when fluid accumulates, but I am rather inclined to believe that these resemble very closely the group of cases which Dr. Dirkse and I reported some time ago as representing lobular ectasia associated with acute respiratory infection.

Dr. Sante (closing). Dr. Ramsey presented in a few words, far better than I could, the case as we thought we saw it. We had not observed anything that quite resembled this, including Dr. Peirce's lobular ectasia, and we sought for the reason. We thought that this might possibly be an explanation; that is, since all these cases were associated with septicemia, with an organism that actually attacked the vessels, causing thrombosis of the terminal vessels, that it might be possible that the actual interference with the nutrition through thrombosis of the bronchial artery might result in a picture like this. However, that is just speculation.

Of course, under such circumstances, the next logical thing to do is to occlude the bronchial

artery and see what kind of a roentgen appearance it will produce; but the bronchial artery wasn't so easy to find. As a matter of fact, we not only at first could not find the bronchial artery but we could not find anybody who knew where it was. In most instances it is not where the anatomy books say it is. It is imbedded in the bronchus, and varies widely in its origin, so that we were not able to carry our investigation any farther.

About 60 cadavers were dissected by one of the anatomy instructors and the findings will be published in one of the anatomy journals. It may be possible with the aid of this information to carry this just a little further.

I am sorry that I did not make myself clear to Dr. Peirce; Case v was the patient who came to autopsy. Roentgenograms showing typical lesions were shown in this case. I do believe, as Dr. Peirce says, that this has to do with an inflammatory process that affects all the structures. There is no question about the little areas of pneumonia that were present in these cases, but we have many of those, of course, which do not have this associated ringlike structures that occurred in these cases. I really wonder if this may not be due to the actual loss of the nutrition of the bronchi, in their terminal stages of division as a result of thrombosis of the terminal branches of the bronchial arteries.

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ROENTGENOGRAPHIC ASPECTS OF MONALDI'S CAVITY ASPIRATION IN PULMONARY TUBERCULOSIS

By WALDO R. OECHSLI, M.D., *Roentgenologist*
Olive View Sanatorium
OLIVE VIEW, CALIFORNIA
and
EDWARD KUPKA, M.D., *Chief*
Bureau of Tuberculosis
California State Department of Public Health

ASPIRATION of a tuberculous cavity by suction through a catheter introduced transthoracically is one of the newer surgical procedures used to bring about obliteration of the cavity. Direct surgical approach to tuberculous cavities has agitated the minds of interested physicians for more than a hundred years, but the first practicable method was worked out by Monaldi[6,7,8,9] in 1938. Up to the present time, over one hundred articles[10] have appeared in the world's literature concerning the Monaldi method, largely in Italian, German and Spanish.

Details of the technique were first decribed in English in 1940.[5] The method consists in barest essence of the introduction through a special cannula of a rubber catheter through the chest wall into the cavity, anchoring of the catheter, and the application of a persistently negative pressure through the catheter over a prolonged period of time.

The first American series of cases was reported from the Olive View Sanatorium.[4] These patients were subjected to intensive roentgenologic study, including the liberal use of body section roentgenography. Cavity aspiration is a novel procedure; it poses difficult roentgenographic problems and yields new information regarding certain aspects of tuberculosis. In preparation for this study, several hundred roentgenograms of the first Olive View series of cases were studied and representative ones were chosen for presentation. The two oldest cases are given in detail.

CASE 1. G. G., a Mexican girl, aged seventeen, developed a "cold" with cough in March, 1938, spitting up a small amount of blood three days after the onset. Diagnosis of active pulmonary tuberculosis was made by a clinic physician and the patient was kept in bed at home until admittance to the Olive View Sanatorium, April 27, 1938. Roentgen examination at this time showed heavy, dense, soft infiltration in the upper third of the left lung, surrounding a 3 by 5.5 cm. cavity; there was evidence of thickening of the walls of the communicating bronchus. On the right a small patch of confluent involvement was seen just below the third rib. The sputum was markedly positive. Patient was febrile, but in good general condition.

Left pneumothorax was begun on May 12, 1938, but it soon became evident that inoperable apical adhesions were suspending the cavity and pneumothorax was discontinued after three months. On August 15, 1938, pneumoperitoneum was begun; this brought about a reduction in the amount of sputum and an occasional negative sputum, but the cavity persisted. Bronchoscopy done just before pneumoperitoneum was begun showed injected granulation tissue in the left upper lobe bronchus with submucosal nodules in the left main bronchus.

Because of persisting soft infiltration in the right lung, a right temporary phrenic paralysis was done on March 6, 1939, in the hope of better preparing the patient for an eventual left thoracoplasty. During the following months, the sputum again became heavily positive, the cavity showed gradual increase in size with some ballooning, and the infiltration on the right showed little material change (Fig. 1 and 2). After needling had demonstrated an

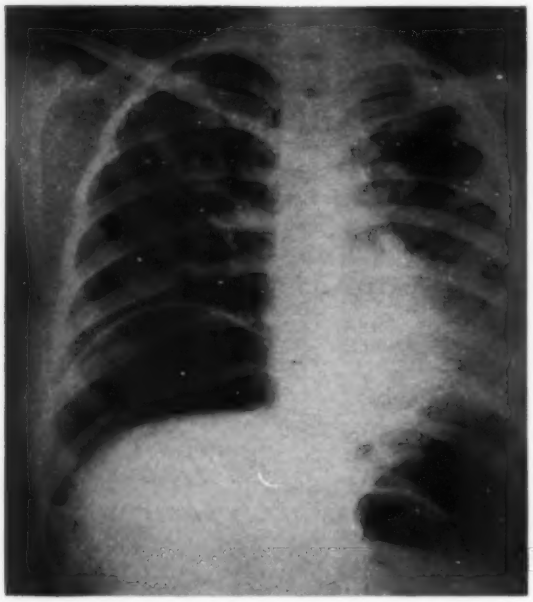

FIG. 1. Case 1. Balloon cavity in left upper lobe extending to third rib.

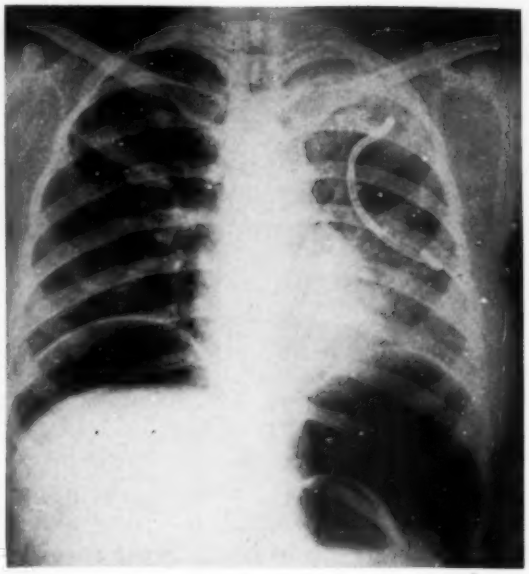

FIG. 3. Case 1. Four days after Figure 1 and three days after Monaldi's suction aspiration was commenced showing no patent cavitation.

obliterated pleural space in the operative area, the cavity was punctured and a catheter introduced through the first interspace on September 28, 1939. There was a small amount of postoperative hemoptysis. On the next morning, suction upon the catheter showed the cavity to contain blood which was aspirated as completely as possible, and the water pump attached to the catheter with suction equivalent to 30 cm. of water. Suction was continued during the daytime from this point on. The roentgenograms of October 2, 1939 (Fig. 3 and 4) showed marked decrease in size of the cavity; the roentgenogram of October 6, 1939, showed no cavity. The catheter moved slowly

FIG. 2. Case 1. Lateral view showing position of cavity above interlobar fissure.

FIG. 4. Case 1. Lateral view showing position of catheter.

outward and the number of bacilli in sputum and catheter drainage decreased rapidly. Planigrams of October 9, 1939, revealed only slight suggestive evidence of cavitation but planigrams of October 18 showed no evidence of patent cavitation, although the tip of the catheter was well visualized (Fig. 5). The sputum became negative on October 8 and continued so for two months. Thirty-five days after the beginning of suction, the catheter, which had pushed out 7 cm., was completely removed. On November 25, 1939, the planigrams showed reopening of the cavity, and on December 28 the sputum again became positive. By March, the cavity had increased again almost to its original size (Fig. 6), and plans were made to repeat the puncture but shortly thereafter the temperature rose, headache developed and on April 29, 1940, the patient died of a fulminating tuberculous meningitis.

Case II. N. F., white female, aged thirty-nine, first noted cough and weakness in February, 1938. Roentgenograms made in July, 1938, were diagnostic of far advanced pulmonary tuberculosis and left pneumothorax was begun in October, 1938, the patient remaining at home until admittance to the Olive View Sanatorium on March 2, 1939. At this time the sputum was markedly positive and the roentgenogram showed an unsatisfactory collapse, the left upper lobe being held out by many broad adhesions which were inoperable. There were two cavities, the largest measuring 4.5 by 6.5 cm.; the right lung showed fine, soft nodulation from the second to the fifth ribs. Pneumothorax was discontinued. Bronchoscopy showed no evidence of tuberculous involvement of the major bronchi or trachea. A left phrenic crush was performed on April 27, 1939.

Fig. 5. Case 1. Rectilinear planigram at 5 cm. level, nineteen days after Monaldi's suction aspiration was commenced. At this level, the tip of the catheter is shown but no patent cavitation.

Fig. 6. Case 1. Planigram at 6 cm. level, four months after removal of catheter from the chest. The cavity has re-opened and is over half the original size.

The roentgenogram of August 15, 1939 (Fig. 7) showed slight increase in the nodulation on the right, disappearance of the pneumothorax, a rather high left diaphragm and one remaining cavity, distinctly balloon type, measuring 4 by 4.5 cm. Needling showed that the left pleurae had become adherent in the operative area, and on October 11, 1939, cavity puncture was done. Suction was started the next day. Sputum decreased rapidly in amount and by November 16 was negative, remaining

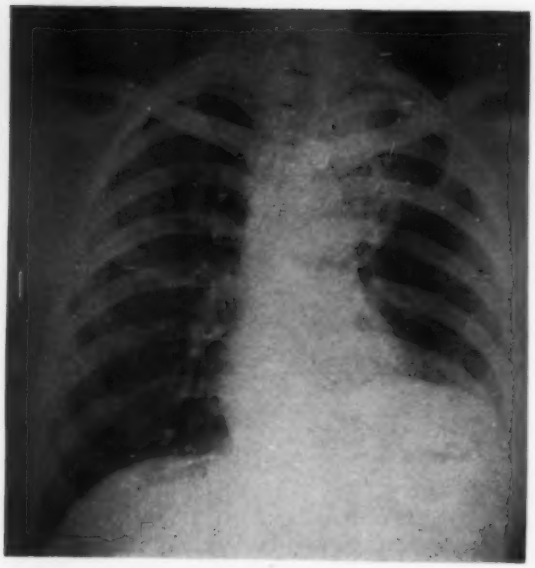

FIG. 7. Case 11. Balloon cavity in left upper lobe extending to second rib.

thus from that date. Roentgenograms showed a rapid decrease in the size of the cavity (Fig. 8) and final closure (Fig. 9). On November 24, 1939, the catheter began pushing out very rapidly, and it was removed two days later after forty-six days of suction. The cavity remained closed in subsequent roentgenograms, exercise was begun in March, 1940, the phrenic paralysis was made permanent in July, 1940, and the patient was discharged to her home in November, 1940.

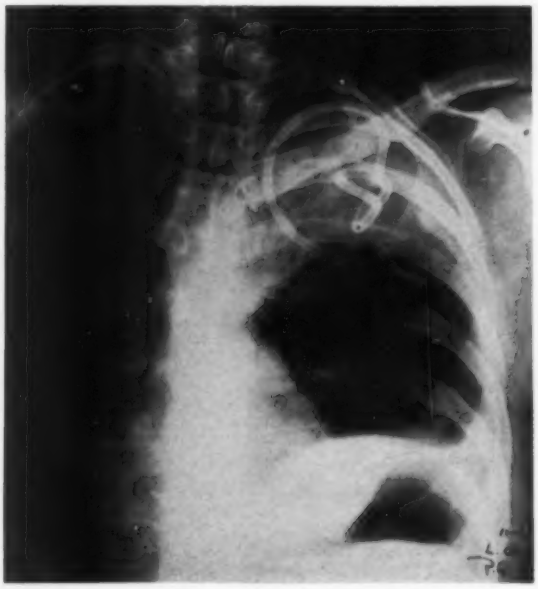

FIG. 8. Case 11. Twenty-five days after Monaldi's suction aspiration was commenced. The cavity has become greatly flattened.

Study of the data gathered from this series of 17 cases reveals facts which bear interest beyond the consideration of the Monaldi method itself.

The cavity punctured in each case was located in an upper lobe. As expected, from various reported studies of localization of cavitation, the cavities were located posteriorly in practically every case, more often just above the fissure between posterior parts of the upper and lower lobes, rather than apical (Fig. 2 and 10). True localization was sometimes possible only after a considerable reduction in size of the cavity for the reason that distention of the cavity was often upward, away from the fissure, making the cavity appear higher in the chest than the point at which it must have originated.

Fig. 9. Case 11. Planigram at 9 cm. level, seven months after removal of catheter showing absence of cavitation. A bronchus can be seen extending toward the original site of the cavity.

The size of the cavities, in the greatest

diameter, varied from 5.5 to 15 cm. All but two of the cavities were distinctly "balloon" or "tennis-ball" type, of a smoothly oval or circular contour; the walls give the appearance of being under tension (Fig. 1, 7 and 10), constituting good indirect evidence of tuberculous involvement of the draining bronchus.[11] These cavities corresponded to Pinner's Type II. The walls of these cavities, for the most part, were of uniform thickness for each cavity but in different cavities varied widely. Subsequent behavior indicated that this apparent cavity wall must have been made up in large part of compressed, airless alveoli. In 2 cases the cavities were irregular in shape, with much probable caseation in their walls and thickening of the overlying pleura (Pinner's Type III). Frequently there was direct evidence of thickening of the walls of the draining bronchi.[11]

The indication for the Monaldi treatment was considered poor in the 2 cases with Type III cavities, and in 3 others with atelectasis in the lobe where the cavity was located and with cavitation in the contralateral lung. This poor prognosis was realized by the subsequent course. In another case, the indication was considered poor because the cavity was a balloon cavity of the highest order, increasing in size with extreme rapidity during the last week before puncture, with very acute symptoms. Aspiration was done in this case as an emergency measure but the subsequent reduction in size of the cavity to a point where thoracoplasty was done with closure of the cavity completely confounded the original prognosis. Thus neither rapid increase in size of cavity nor thickness of walls of the cavity, when due to compressed alveoli, proved to be contraindications to the Monaldi method but rather direct indications for the institution of suction. The ideal indications from the roentgenologic standpoint would seem to be a balloon cavity with thin walls (or, if thick, due to compressed alveoli and not caseation), located in an upper lobe, accessible to anterior approach, surrounded by fairly well aerated lung tissue (no lobar atelectasis), with a minimum of overlying thickened pleura. The disease process should be of comparatively recent origin and there should be no other cavities.

FIG. 10. Lateral view of a patient showing typical balloon type cavity with fluid level suggesting pathological involvement of the communicating bronchus.

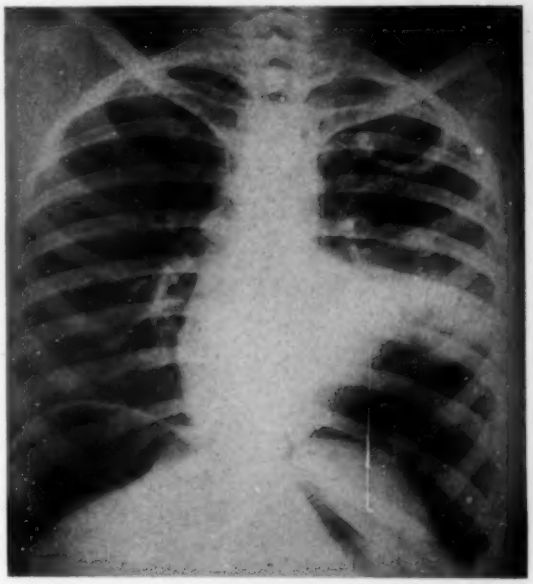

FIG. 11. Balloon cavity before Monaldi's suction aspiration was commenced.

FIG. 12. Same patient as in Figure 11 after suction. The cavity, located below the tip of the catheter, is now very thin walled, suggesting re-aeration of compressed alveoli.

Accurate localization of the cavity is essential for this operation. This may be done by Johnson's method of localization,[3] roentgenoscopic examination, rotating the patient before the screen, by body section roentgenography or by lateral roentgenograms. The lateral view was used in all these cases as well as other methods. By means of the lateral view the size of the cavity in the third dimension can be determined; in addition, the distance between the anterior chest wall to the anterior wall of the cavity can be determined with a fair degree of accuracy. There may be slight error if the chest wall slopes away rapidly from the sterum or if the patient has a funnel chest. To obviate this error one can measure from the anterior extremity of a rib or a marker placed on the skin where puncture is contemplated. The roentgenogram must represent a true lateral view.

At the time of puncture of the cavity, the patient is roentgenoscoped in the supine position and the cavity again localized in relation to the ribs of the anterior chest wall. By coning down to a small aperture with the diaphragm, a spot can be selected which is vertically over the cavity and located at or near an intercostal space. This spot is marked and is used, after sterilization of the skin, for the point of entry of the needle and later the trocar downward through the chest wall in a vertical direction. The lower surface and sides of the fluoroscopic screen are draped with a sterile sheet so that roentgenoscopy can be employed in the course of the operation if desired to check the position of the needle or trocar. The depth of the needle cannot be checked in this way unless one has available a bi-plane fluoroscope. Entry into the cavity is judged only by the more or less sudden "give" of the needle and by manometric readings.

The most dramatic change, as seen in the roentgenograms made a few days to a week after puncture and institution of suction, is a very rapid decrease in the size of the cavity, which occurred in about half the cases

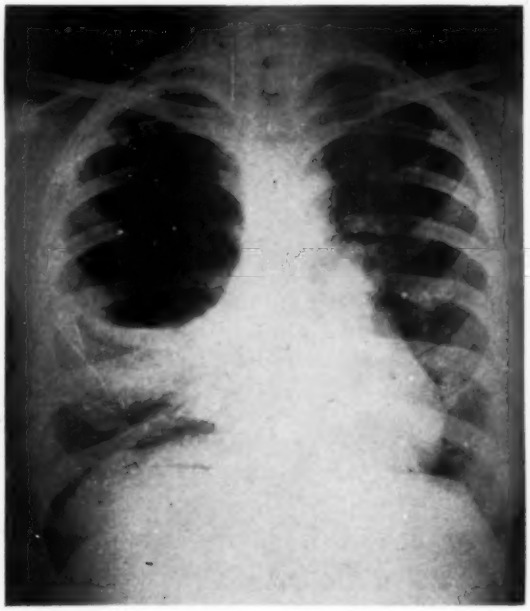

FIG. 13. Huge balloon cavity which was increasing rapidly in size before puncture, with increasingly acute symptoms.

(Fig. 13 and 14). This favorable early response was seen chiefly in those patients whose cavity had ballooned shortly before puncture. Associated with this decrease in size, cavities lost the appearance of being under tension. After the initial decrease in size, further diminution in most cases was much slower. In the cases where there was considerable caseous involvement in the walls of the cavity, any decrease in size which occurred was gradual and slow from the start.

The changes which occurred in the lung surrounding the cavity under aspiration were of unexpected interest. In the majority of the patients there was a very definite increase in density immediately around the cavity (Fig. 8 and 15). Usually this increased density was most noticeable above and lateral to the cavity and extended entirely to the chest wall. These changes occurred early and persisted for a number of weeks or months. Eventually, there was usually gradual clearing or absorption of the pathological condition causing the density. However, there remained in most instances along the chest wall, opposite the location of the cavity, well defined evidence of thickening of the pleura which had not been present before aspiration (Fig. 14 and 16). Along with this, there was often the appearance of a "pleural spike," a discrete linear shadow extending from the pleura toward the site of the cavity. These final changes are often seen following spontaneous healing of a cavity. One might therefore venture the inference suggested by Coryllos' theories of cavity closure, that where cavities close by complete blocking of the communicating bronchus, there is a high negative pressure within the cavity, comparable to that produced deliberately by the Monaldi method.

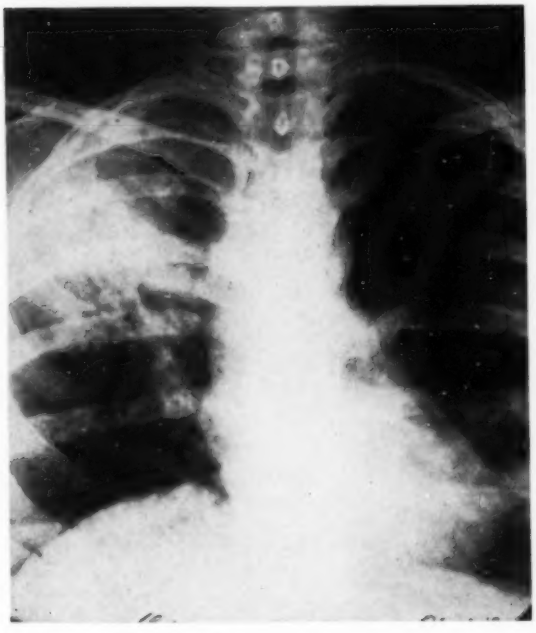

Fig. 14. Same patient after Monaldi's suction aspiration, showing marked decrease in size of cavity, re-aeration of compressed alveoli, and increased pleural shadowing laterally over the upper lobe.

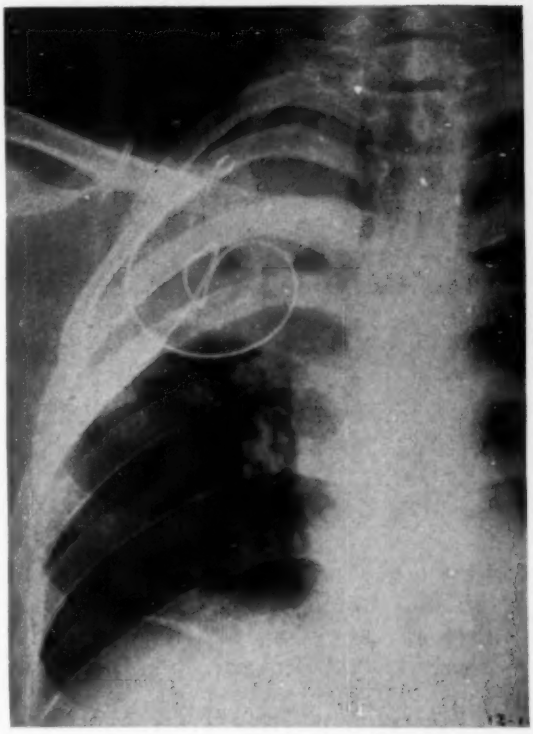

Fig. 15. Marked increase in pleural shadowing over lateral aspect of upper lobe following Monaldi suction. The catheter used in this patient was a gum rubber catheter which is non-radiopaque, requiring iodized oil to outline it.

Another striking change observed was a progressive increase in distance between the wall of the cavity and the chest wall

laterally and the mediastinum mesially, as the cavity decreased in size. There was usually little or no intervening distance before aspiration, while after aspiration this distance increased as much as 5 cm. (Fig. 7, 8, 13 and 14). This is obviously a compensatory phenomenon associated with decrease in volume of the cavity and appears to confirm Monaldi's theory of atelectasis of the alveoli immediately surrounding the cavity.

In the earlier cases, a radiopaque catheter was used and its position could be accurately determined by roentgenography. Later, a gum rubber catheter was used and it was necessary to fill it with 1 to 2 cc. of iodized oil. By this means, the position of the catheter, its length remaining in the cavity, and its disposition therein can be determined (Fig. 3, 4, 8 and 15). In some cases, a small amount of iodized oil spilled into the cavity and even into the communicating bronchus.

Roentgen examination is necessary at more frequent intervals in aspiration cases than with any other form of treatment except possibly thoracoplasty. Posteroanterior and lateral roentgenograms are needed a few days after puncture of the cavity. Therefore, monthly examination suffices, except in the advent of an emergency.

As the cavity becomes smaller under suction, it also becomes much more irregular in shape, often becoming markedly flattened down around the catheter with little or no patency demonstrable. This fact, together with localized emphysema, which often appears around the site of the cavity, during the healing process, and the thickened pleura overlying the cavity often prevents accurate delineation of the cavity in conventional roentgenograms. Body section roentgenography thus becomes a prime requisite to determination of cavity closure (Fig. 5 and 9). For this method, we used a rectilinear planigraph constructed by our

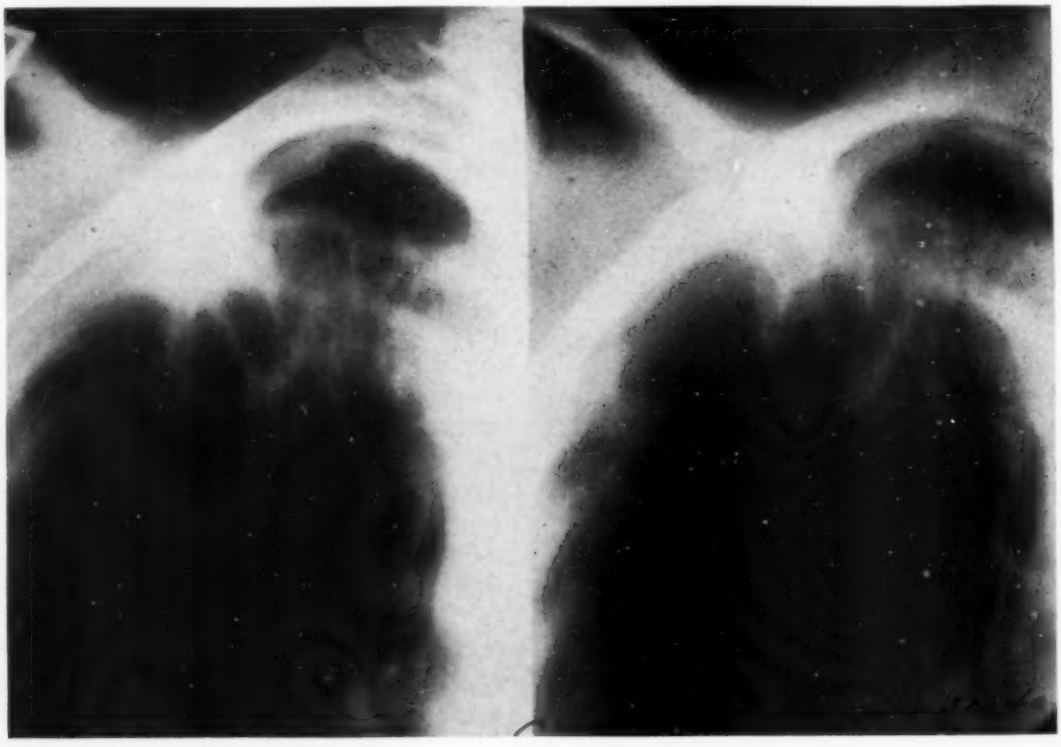

FIG. 16. Planigram of right upper lobe six months after unsuccessful aspiration treatment, showing thickening of pleura laterally opposite the cavity. A lobectomy was later performed on this patient.

Fig. 17. Planigrams in the area between the cavity and the anterior chest wall, in same patient as in Figure 16. showing the catheter with a fair sized tract around it and rather dense parenchymal involvement around the tract.

mechanics. It is similar to the planigraph since described by Chamberlain and Young.[1] In the 7 patients in whom the cavity eventually closed by suction, it was necessary to employ the planigraph to determine this fact. Most of the remaining 10 patients showed undoubted evidence of persistence of cavitation by conventional roentgenograms, but in some, cavitation undoubtedly would have been pronounced closed had not planigrams shown undisputed evidence of cavitation persisting. In one instance iodized oil was purposely introduced into the cavity to outline its size and extent. Because of slight reaction, it was not attempted in other cases, although Monaldi advocates free use of this method.[2]

A finding which practically required the use of the planigraph was the determination of the presence and size of the tract between the cavity and the anterior chest wall, both during the time it is occupied by the catheter and after its removal. Body section roentgenograms at intervals through this tract showed that in some cases there was no air space around the catheter and little or no abnormal density of the surrounding lung tissue. In others, an open space measuring up to 1 cm. immediately around the catheter and extending to the anterior chest wall was clearly seen (Fig. 17). The lung tissue around this tract was rather densely infiltrated. Persistence of the tract was diagnosed in some cases even after permanent healing of the dermal wound. This was confirmed in 2 cases by subsequent lobectomy.

CONCLUSIONS

The roentgenologic aspects of seventeen cases of pulmonary tuberculosis in which Monaldi's method of aspiration was used in the treatment of cavities are described, and two case histories given. All but two cavities were of the balloon type and the most prompt results were obtained in these

cases. The results in two Type III cavities with probably caseous walls were slow and poor. Behavior of the cavity wall in some patients appears to substantiate Monaldi's contention that the cavity wall in many instances is partially made up of compressed, airless alveoli, rather than pathological material. An increase in dense shadowing over the part of the lung containing the cavity, noted by others using this method, appears to be due in part to localized pleural changes which may be associated with the high negative pressure produced in the cavity by this treatment. The state of the tract occupied by the catheter traversing the lung between the cavity and the chest wall is best determined by body section roentgenography. This method of examination is also a prime requisite to determination of cavity closure.

REFERENCES

1. CHAMBERLAIN, W. E., and YOUNG, B. R. Simple method of adapting conventional roentgenologic equipment to body section roentgenography (planigraphy). AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *44*, 638–639.
2. CHIODI, S., and GEMMI, M. Le vie bronchiali di drenaggio nell' aspirazione endocavitaria. *Ann. Inst. Carlo Forlanini*, 1940, *4*, 733.
3. JOHNSON, C. R. Roentgen localization of intrathoracic structures, with report of findings in 19 cases of lung abscess. *Am. J. Surg.*, 1930, *8*, 1237–1240.
4. KUPKA, E., and BENNETT, E. S. Monaldi's suction aspiration of tuberculous cavities. *Am. Rev. Tuberc.*, 1940, *42*, 614–621.
5. KUPKA, E., and WELLS, R. Technique of cavity aspiration (Monaldi). *Am. Rev. Tuberc.*, 1940, *42*, 401–411.
6. MONALDI, V. Tentativi di aspirazione endocavitaria nelle caverne tubercolari del pulmonale. *Lotta contro la tuberc.*, 1938, *9*, No. 9.
7. MONALDI, V. Procedimento di aspirazione endocavitaria delle caverne tubercolari del pulmonale. Basi teoriche. *Ann. Inst. Carlo Forlanini*, 1938, *2*, No. 10.
8. MONALDI, V. Ueber die Saugdränagebehandlung tuberkulöser Lungenkavernen. *Ztschr. f. Tuberk.*, 1939, *82*, 273–283.
9. MONALDI, V. Applicazione del procedimento di aspirazione endocavitaria, centoquaranto casi con resultato favorevole. *Ann. Inst. Carlo Forlanini*, 1940, *4*, No. 9.
10. MONALDI, V. Ueber die Saugdränage der tuberkulösen Lungenkavernen. *München. med. Wchnschr.*, 1941, *88*, 453–459.
11. OECHSLI, W. R. Tuberculous tracheobronchitis: roentgenographic appearance. AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *46*, 312–320.

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SMALL INTESTINAL ENEMA*

By RICHARD SCHATZKI, M.D.
BOSTON, MASSACHUSETTS

THE examination of the small intestine has always been a stepchild of roentgenology. In all other parts of the gastrointestinal tract the examination is performed by observing roentgenoscopically the actual filling of the organ in question and then by studying the partially or completely filled organ. If the usual roentgenological methods are used such an examination of the small intestine is not possible due to the obstacle which the pylorus causes in the continuous outflow of barium.

It seemed likely that a satisfactory examination of the small intestine would become possible if the barium were introduced through a duodenal tube. In this way the filling of the small intestine would become similar to that of the colon through a rectal tube; it would in fact be an enema examination of the small intestine. The initial tests were surprisingly satisfactory.

A review of the literature showed that a similar procedure had been proposed independently in three previous publications. Various authors had used a tube in order to study the duodenum roentgenologically, but Pesquera[3] (1929) was apparently the first to recommend the use of the duodenal tube for a continuous filling of the small intestine in the sense outlined above. He was followed by Ghelow and Mengis[2] (1938) and by Gershon-Cohen and Shay[1] (1939). The last two authors called the method barium enteroclysis. All essential features of the subject are contained in their short but comprehensive article. We have used the tube examination of the small intestine (at first without knowledge of the preceding publications) in approximately 75 cases. The results have been encouraging enough to recommend its use as a routine procedure.

METHOD OF EXAMINATION

Aside from the necessity of an empty stomach, a special preparation is not required. An empty colon is helpful but not obligatory. A soft rubber tube with a metal olive tip (Rehfuss tube) is introduced into the duodenum through the mouth. In sensitive patients it may be advisable to insert the tube without the olive through the nose and attach the olive when the tip of the tube has appeared in the oral pharynx. The patient is ready for the examination as soon as the olive is in the duodenum.

As contrast substance we use a mixture which is thinner than that used for our usual gastrointestinal examination (equal parts of water and barium by volume). For the small intestinal enema two glasses of lukewarm water are added to one glass of the usual barium mixture. This corresponds approximately to 6 parts of barium to 20 parts of water by volume. Some patients complain of uncomfortable sensations in their throats unless the mixture is lukewarm.

Five hundred to 1,000 cc. are necessary to examine the small intestine. In cases with marked reflux of barium into the stomach larger amounts have been used occasionally but have proved to be of no help.

In order to inject the barium mixture, we started by using a syringe. We now find it more advantageous to let the barium run from a small pint container (transfusion flask) which the attendant holds over her head. This guarantees a more continuous flow of the barium, which we believe to be essential for the success of the examination. In most instances the pylorus prevents an appreciable amount of barium from getting into the stomach, but in some cases there is a very disturbing reflux into the stomach.

* From the Department of Radiology, Massachusetts General Hospital, Boston, Massachusetts. Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.

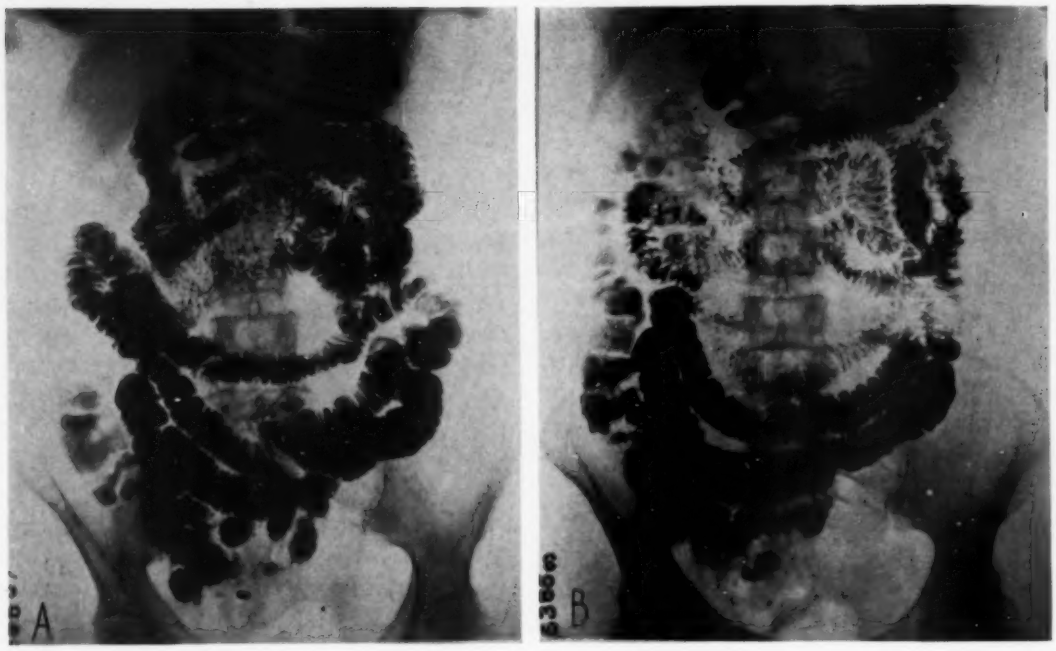


FIG. 1. Normal small intestinal enema. The ileocecal valve was reached at the end of eleven minutes. *A*, roentgenogram taken sixteen minutes after the beginning of the examination. *B*, roentgenogram taken thirty-six minutes after the beginning of the examination.

This reflux is usually not remedied, as might be expected, by lowering the enema can and thereby decreasing the duodenal pressure. For one thing, lowering of the can beyond a certain point is impossible without impeding the progress of the barium column; for another, the reflux is dependent not only on pressure in the duodenum, because it may occur in a patient whose duodenum is incompletely filled.

The filling of the intestine is observed roentgenoscopically. In most normal cases it is possible to follow the head of the barium column; in other cases it is not possible, because the filling of the small intestine is retarded, usually by reflux of barium into the stomach.

In order to avoid overexposure, it is advisable to roentgenoscope with only 2 to 3

FIG. 2. Normal small intestinal enema in a patient with colonic polyposis. (The cecum was reached in eight minutes. This roentgenogram was taken fifteen minutes after the beginning of the examination.)

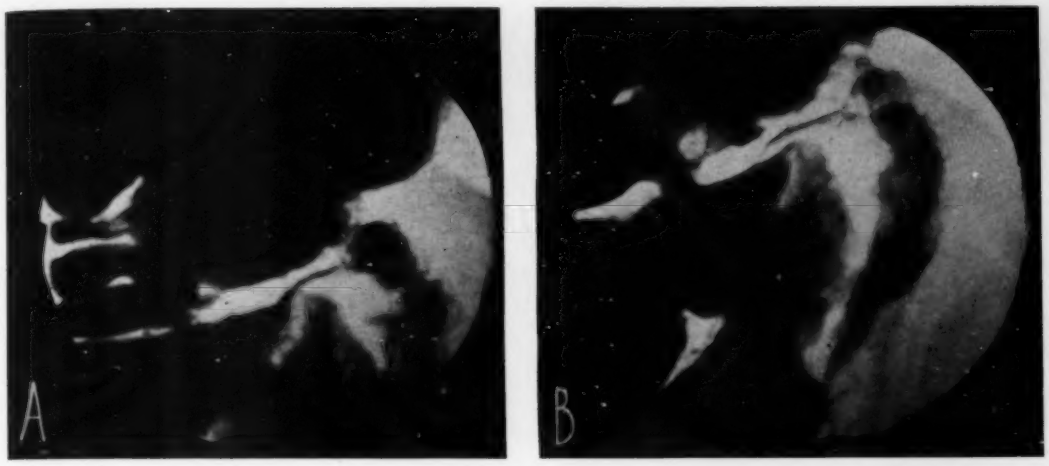


Fig. 3. Normal ileocecal valve demonstrated by small intestinal enema.

ma., which will provide a perfectly satisfactory light for examination of the small intestine. Care should be taken to keep the total time of roentgenoscopy within the zone of safety.

The barium reaches the cecum in a surprisingly short time. In 35 normal cases the

Fig. 4. Clinical diagnosis: actinomycotic abscess in right flank; questionable involvement of cecum and ileum. Small intestinal enema: mass displacing cecum and ileum; no involvement of the intestines. (Cecum was reached in thirteen minutes. This roentgenogram was taken at the end of thirty minutes.)

Fig. 5. Clinical diagnosis: treated cancer of cervix; question of intestinal obstruction. Small intestinal enema: three loops of small intestine adherent to pelvic mass (see arrows); no obstruction at present. Congenital absent rotation of small intestine as an accidental finding. (Cecum was reached at the end of thirty-five minutes. This roentgenogram was taken at the end of twenty-seven minutes.)

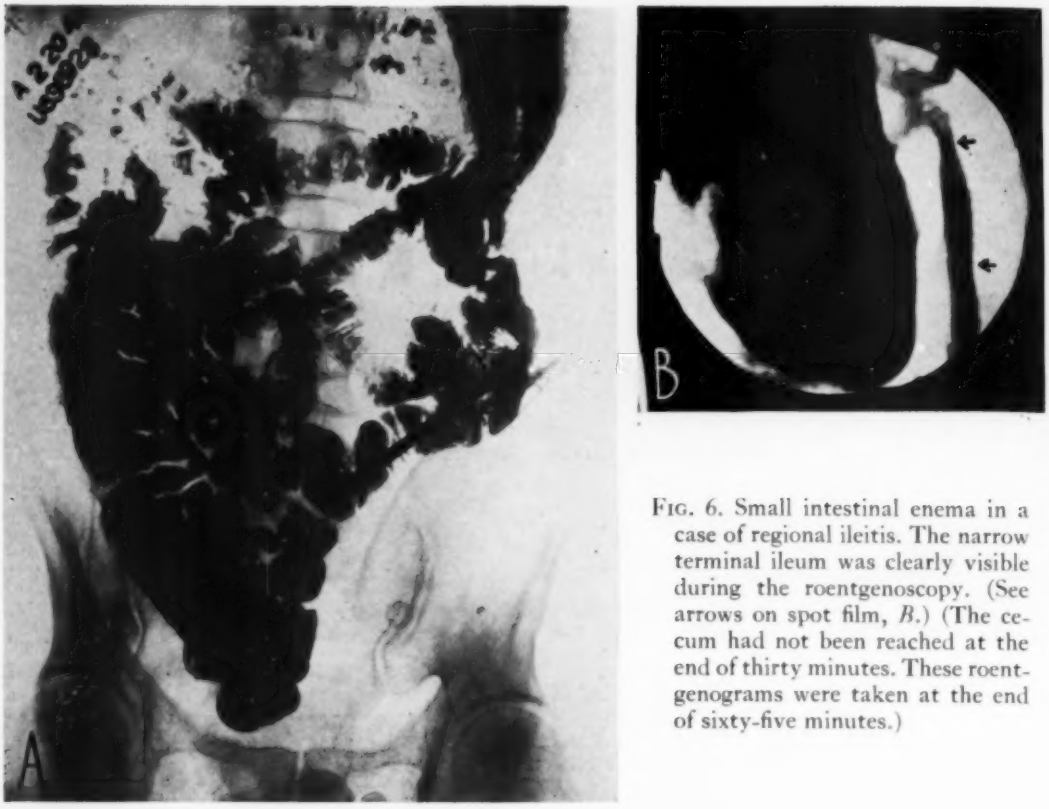


Fig. 6. Small intestinal enema in a case of regional ileitis. The narrow terminal ileum was clearly visible during the roentgenoscopy. (See arrows on spot film, *B*.) (The cecum had not been reached at the end of thirty minutes. These roentgenograms were taken at the end of sixty-five minutes.)

average time was fifteen minutes. The earliest filling of the cecum occurred in five minutes. In 4 normal cases only did the filling require more than twenty minutes (22, 26, 30 and 90 minutes). In all except the first of these cases marked reflux of barium into the stomach caused the delay. In most pathological cases more time was required, the average being thirty-seven minutes in 19 checked cases.

Fig. 7. Extensive regional ileitis (arrows). Small intestinal enema outlines not only the disease but also the approximate length of the uninvolved small intestine. (The cecum was reached at the end of fifteen minutes. This roentgenogram was taken at the end of ninety minutes.)

Constant flow of the enema fluid is necessary. Any interruption will delay the examination markedly. The impression is sometimes gained that the filling of the small intestine actually has to start anew after an interruption.

Ghelew and Mengis, as well as Gershon-Cohen and Shay, have used insufflation of

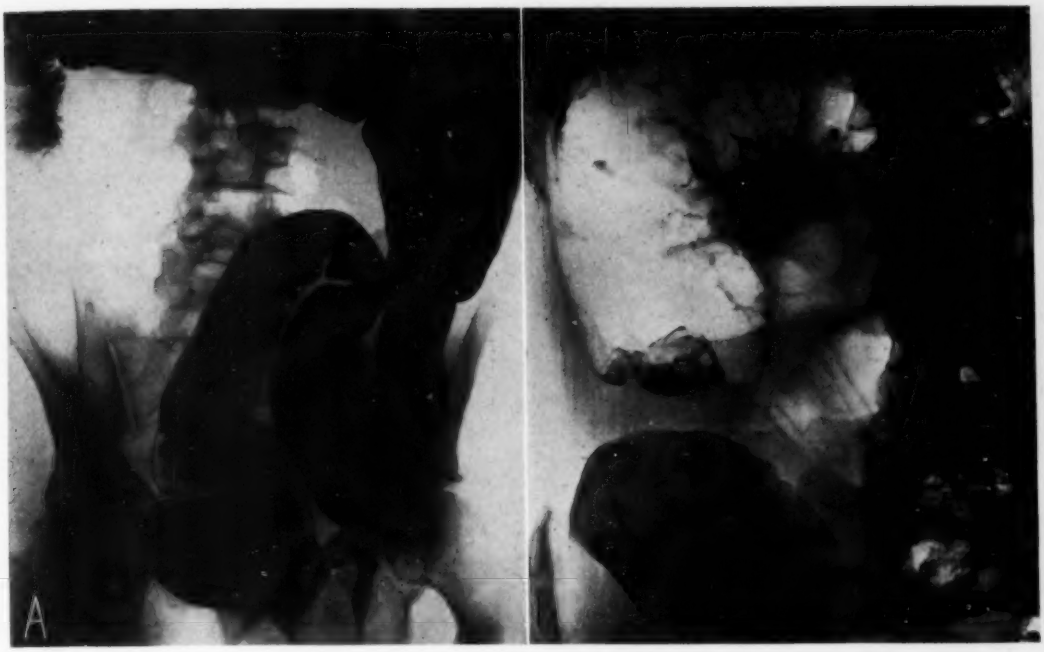


Fig. 8. Ileocecal tuberculosis. Routine barium enema shows obstruction which was erroneously interpreted as a mass in the lower cecum. *A*, before evacuation; *B*, after evacuation and air insufflation. (See also Fig. 9 of the same case.)

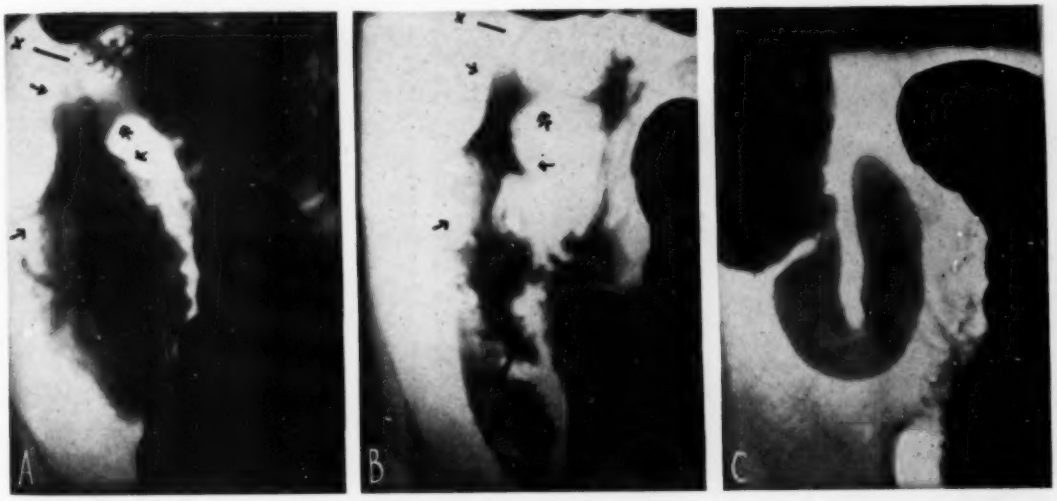


Fig. 9. Same case as in Figure 8. Ileocecal tuberculosis. Small intestinal enema outlines the ulcerated tumor-forming lesion which involves the lower ascending colon and the upper fourth of the cecum (see single arrow). The point of obstruction lies in the ascending colon, and not in the cecum (*X*); the ileocecal valve appears stiff (see double arrow); neither the lower part of the cecum nor the ileum was involved, as is shown by their normal elasticity. Note the distended ileum in *A*, and the distended cecum and appendix in *C*. (The dense shadows on the right side of the figures are produced by the palpating glove.)

air through the duodenal tube for double contrast studies. We have had no experience with this method.

ADVANTAGES OF THE METHOD

1. The small intestine is seen filled in its entirety. The resulting advantages are manifold. Circumscribed lesions can be excluded with more certainty. However, in our series of approximately 75 patients, we have not seen either a small tumor or a Meckel's diverticulum. The position and the relationship of various groups of small intestinal coils can be studied reliably. The presence or absence of small portions of intestine within a hernial sac can be readily visualized. The accurate demonstration of the site of a small intestinal fistula is made possible. In cases of cicatrizing enteritis the length of grossly normal bowel proximal to the diseased area can be estimated with greater accuracy than with the usual method, a fact which may be of decisive importance concerning the operability of a given case (Fig. 7).

2. The actual filling of the small intestinal loops can be observed roentgenoscopically. The ensuing advantages for the discovery and study of pathological conditions are obvious. The extent of a lesion, its relationship to neighboring structures, and the presence or absence of rigidity can be judged with greater accuracy than with the usual methods. In cicatrizing enteritis the barium at times is spurted through the region of maximal narrowing, preventing its demonstration unless the filling is actually seen during the enema examination.

3. Due to the dehydration of the barium mixture the usual peroral examination of the small intestine often results in a lumpy incomplete filling of the ileum. The small intestinal enema transports the barium to the ileum in such short time that notice-

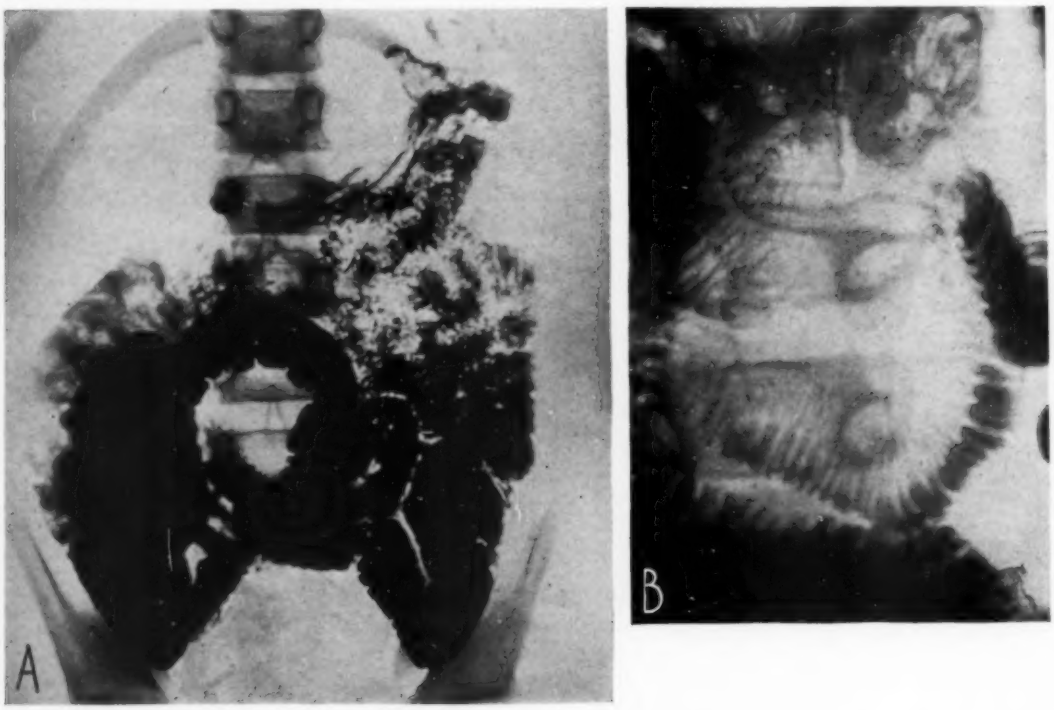


Fig. 10. Extrinsic mass clearly outlined by the small intestinal enema (abdominal lymphoma). The defect was constant during roentgenoscopy as shown by spot film, *B*. Compare with Figure 11. (Lower defect produced by the filled urinary bladder.)

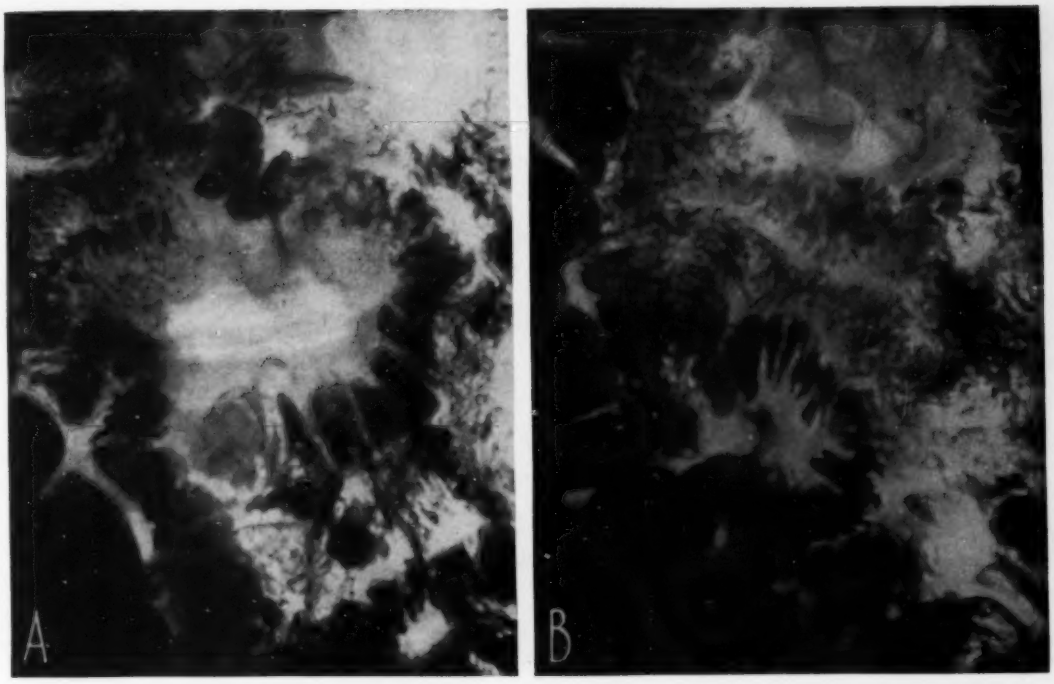


Fig. 11. Pseudo-tumor, commonly seen, produced by interposition of non-filled loops of intestine or by omentum. Note disappearance of pseudo-tumor in expiration in contradistinction to true extrinsic tumor (Fig. 10). *A*, inspiration; *B*, expiration.

able dehydration does not take place.

4. An adequate examination of the ileocecal valve, the cecum, and the ascending colon, with a *fluid* barium mixture, is made possible in all those cases in which an examination by rectal enema is impossible or unsatisfactory (e.g., in anal insufficiency or in spasm of the cecum and ascending colon). (See Fig. 3, 8 and 9.)

5. The time which is required for the actual examination is shortened. The reduction of time is particularly striking in that large group of normal cases in which a pathological condition is to be excluded. In cases with a marked pathological condition the filling time of the small intestine is occasionally no shorter than with the conventional method.

Fig. 12. Small intestinal enema in a patient with tuberculous peritonitis. Rapid filling of the small intestine, the cecum being reached at the end of six minutes; fixed position of the small intestinal loops. The small intestine has risen out of the true pelvis and occupies a smaller space than usual. The peritoneal cavity was found to be obliterated at operation.

DIFFICULTIES CONNECTED WITH THE METHOD

1. The method requires the introduction of a duodenal tube with its usual annoyances and difficulties. With a little experience and patience on the part of the examiner this procedure is not too difficult, and is successful in the great majority of cases. At the beginning of our studies we kept a record of our failures. In only 3 out of 38 attempts did the tube fail to enter the duodenum. The introduction of the duodenal tube is much easier than that of the Miller-Abbott tube, and is, in fact, practical for office procedure.

2. The purpose of the examination is defeated if the filling of the small intestine takes place very slowly, which in normal cases is usually due to reflux of barium from the duodenum into the stomach. Fortunately, cases with marked reflux are the exception, and when they are encountered the progress of the barium can be hastened by having the patient lie partially (or if necessary, completely) on his right side. Attempts to reduce reflux by the addition of an acid buffer to the barium mixture have failed so far to show result, as has decrease in the amount of hydraulic pressure applied, or increase in the amount of barium mixture used.

3. The primary purpose of the method is the demonstration of organic pathology. Functional changes as well as a combination of functional and organic lesions as seen at times in deficiency disease are usually studied better with the conventional type of follow-up examination. The use of *both* methods has been worth while in some conditions.

CONTRAINDICATIONS

Aside from occasional slight cramping pains, which are easily overcome by lowering the enema can, we have not seen any harmful effect from the small intestinal enema. It seems wise, however, to state conditions which are believed to contraindicate the examination:

1. Obviously, the examination should not be performed in any case in which the *routine* examination of the gastrointestinal tract is contraindicated. Therefore, the small intestinal enema is contraindicated in cases with marked mechanical or paralytic ileus. It has been used successfully, however, in several cases of partial obstruction of the small bowel.

2. A small intestinal enema should not be performed in cases with suspected gangrene of the bowel (e.g., mesenteric thrombosis, incarcerated hernia).

3. It seems inadvisable to use the small intestinal enema in patients with an active duodenal ulcer. As a routine procedure it is therefore better to precede the enema by an examination of the stomach and duodenum. The method has been used without difficulty in several cases of old inactive duodenal ulcer.

CONCLUSION

The small intestinal enema represents an improvement in the examination of the small intestine. If successful, it is better than any other available method for the study of morphological changes in the small intestine. The advantages and limitations of the method are discussed.

REFERENCES

1. GERSHON-COHEN, J., and SHAY, H. Barium enteroclysis; method for direct immediate examination of the small intestine by single and double contrast techniques. AM. J. ROENTGENOL. & RAD. THERAPY, 1939, *42*, 456–458.
2. GHELEW, B., and MENGIS, O. Mise en évidence de l'intestin grêle par une nouvelle technique radiologique. *Presse méd.*, 1938, *46*, 444–445.
3. PESQUERA, G. S. Method for direct visualization of lesions in small intestines. AM. J. ROENTGENOL. & RAD. THERAPY, 1929, *22*, 254–257.

DISCUSSION

DR. ROSS GOLDEN, New York City. Although, as Dr. Schatzki said, he did not invent this method, nevertheless he has done us a great service in calling it to our attention and in showing us how useful it can be. I am wondering whether it might not be an advantage to use a tube with a balloon on it, like the Miller-Abbott

tube, which could be inflated when the tip gets into the duodenum and which would promptly be carried around into the jejunum so that barium would be injected into the jejunum and not into the duodenum, thereby avoiding the reflux into the stomach.

The injection of so much water into the small intestine is, of course, not physiological. One function of the intestine is to make isotonic either hypotonic or hypertonic solutions. The question might be raised as to whether it would be of advantage to use normal saline instead of water as the suspending medium to avoid that part of the unphysiological condition. There are obviously certain cases in which this method is particularly indicated. I should like to show a couple of slides to illustrate one such case.

This patient was a colored woman about thirty-seven years old, who was bleeding from the intestine and had developed severe secondary anemia and hypoproteinemia. Her serum protein was about 5.5. A regular small intestine study was done which showed marked segmentation but no cause for the bleeding was demonstrated. A Miller-Abbott tube was then inserted and a specimen was taken at every foot as it went in. At about 6 feet a positive guaiac test was obtained. The patient was explored and a polypoid adenocarcinoma of the lower jejunum about 3 cm. in diameter was removed. It seems as though we should have been able to demonstrate a mass that large in the lumen of the small intestine. However, the disturbance in intestinal physiology resulting from the hypoproteinemia, with very irregular distribution of the barium due to the marked segmentation, made its detection impossible. If we had injected barium as described by Dr. Schatzki, we might have been able to demonstrate that tumor.

On the other hand, we tried this method in another case in which we had been unable to demonstrate a cause for intestinal hemorrhage on five or six attempts with a small intestine study. A small intestinal enema was done and again a lesion was not demonstrated. At operation a patch of gastric mucosa was found in the ileum in which were two ulcers.

This method, I believe, should be accepted as another string to our bow, so to speak. I should not like to substitute it for the routine small intestine study as we are now using it, because the latter has given us information which I do not believe one could get satisfactorily with this method, but I do believe a small intestinal enema will be valuable in selected cases.

Dr. Schatzki (closing). I thank Dr. Golden very much for his discussion. In regard to the use of saline solution, I was worried for a while about washing out the whole small intestine, in fact cleaning it out with the enema, but actually nothing seemed to happen. The patients felt perfectly all right. The method is certainly unphysiological as are all our routine barium examinations of the gastrointestinal tract. I wonder whether the use of saline solution would make the procedure more physiological.

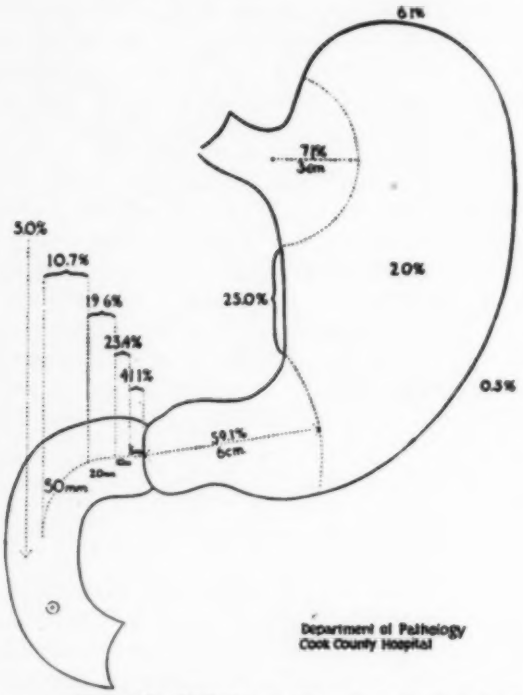
We first thought that it would be necessary to introduce the tube down to the jejunum. The position of the tube in the jejunum proved, however, to be no definite protection against reflux of barium into the stomach. Although a position of the tube low in the duodenum or in the first loop of jejunum is desirable, a successful examination is possible as long as the tip lies beyond the pylorus.

A few words in regard to those small lesions which escape one or several examinations: I think the small intestine is the most difficult part of the intestinal tract to examine because it has such an extremely thin wall and is so markedly flexible. There may be quite a large lesion occupying one-fourth of the circumference and still the flexibility of the remaining three-fourths makes the intestine appear completely normal.

ULCER IN THE DESCENDING DUODENUM*

By CHAUNCEY N. BORMAN, M.D.†
MINNEAPOLIS, MINNESOTA

DUODENAL ulcer develops infrequently beyond the bulb or first portion. The small number of reported cases of ulcer in this location diagnosed by roentgen examination compared to the necropsy incidence suggests that in many instances these ulcers may have been overlooked. The recent demonstration of 7 cases of ulceration in the upper descending duodenum has directed our attention to the infrequency of reported cases of ulcer in this particular location.



—Topographic distribution of 196 gastric and 158 duodenal ulcers.

FIG. 1. Actual site of duodenal peptic ulcer based on observations at necropsy. (Portis and Jaffe.[13] Reproduced through the courtesy of the *Journal of the American Medical Association.*)

In determining the actual location and incidence of duodenal ulcer, necropsy statistics offer the most reliable information. Probably the most recent as well as accurate study is that of Portis and Jaffe[13] from the Cook County Hospital in Chicago. These authors have measured with precision the distance of the ulcer from the pyloric valve in a series of 158 cases of pathologically active ulcer observed in over nine thousand necropsies. Practically 85 per cent were found within the first 2 centimeters of the duodenum, 10 per cent were within the next 3 cm., and 5 per cent were beyond the first 5 cm. and above the papilla of Vater (Fig. 1). Sturtevant and Shapiro[16] in 1926 reviewed 7,700 necropsy cases from Bellevue Hospital and gave the location of 47 duodenal ulcers as follows: 39 (83 per cent) in the first portion, 8 (17 per cent) in the second portion. Perry and Shaw[12] in a report from Guy's Hospital, covering 17,652 autopsies in which there were 149 cases of ulcer, found 16 (11 per cent) in the second portion. Surgical statistics in general do not offer much pertinent evidence as to the exact location or actual incidence of ulcers beyond the pylorus, especially those distal to the usual location in the first one-half inch of the duodenum. Moynihan[10] stated that because of posterior fixation of the duodenum, which is often present, the location of an ulcer by direct inspection may be in error. Demirleau[6] who suggested a racial tendency, found second portion ulcers in 16.7 per cent of 60 operated cases of duodenal ulcer. He emphasized the difficulty of accurate localization because of extensive scar tissue induration and retraction on the inner side of the duodenum. Judd[7] of the Mayo Clinic reported that excised specimens revealed that ulcers may occur beyond the bulb, and he mentioned 2 or 3 instances wherein the ulcer was at the level of the ampulla of Vater. Brule and his associ-

* From the Department of Radiology and Physical Therapy, University of Minnesota.
† Clinical Instructor in Radiology, University of Minnesota Medical School.

ates[2] found 94 reported cases of ulcer in the descending duodenum, and the exact location was given in 43 instances. In 36 (84 per cent) the ulcer was between the superior flexure and the ampulla of Vater.

The percentage of cases of extrabulbar ulcer diagnosed by roentgen examination is apparently smaller than necropsy or surgical statistics indicate. Reports in the American literature are infrequent and do not approach the figure of 5 per cent for the descending portion of the duodenum that necropsy statistics have established. Case[3] in 1916 in a paper entitled "Roentgen observations on the duodenum with special reference to lesions beyond the first portion" stated that no ulcer had ever been recognized by him. Crane[4] in 1922 reported that in his experience "exactly one in a hundred are below or beyond the bulb." Robinson[14] in 1934 pointed out that authors writing on the subject of ulcer have strangely neglected a much needed description of the roentgen signs of extrabulbar ulcers. His report was based on 10 operated cases, but the number in which the roentgen diagnosis was made was not stated. Sussman[17] in 1935 in a report on 8 cases of inflammatory stenosing lesions of the descending duodenum demonstrated a typical crater in 1 case. The remaining 7 cases were stenosing lesions associated with gastric or duodenal bulbar ulcers or primary duodenitis. It should be stated in this connection that primary duodenitis, a diffuse inflammatory process involving the duodenum, may produce superficial abrasions of the mucosa but is usually considered a separate entity. Its relationship to primary or localized peptic ulcer is not as yet clear. Practically no mention of the roentgen diagnosis of ulcers distal to the cap is made in the standard American textbooks of roentgenology.

In the foreign literature, Brule and his associates[2] reported having made the roentgen diagnosis in but 1 case in a number of years' experience, while Demirleau[6] similarly reported but 1 demonstration in 10 operated cases of extrabulbar ulcer. Wolke[19] reviewed the duodenal material of the Mariakrankenhaus in Stockholm and found 12 cases in which the roentgen diagnosis of ulcer of the descending duodenum had been made, 5 of which were verified at operation or autopsy. In all of these cases the ulcer was found in the region of the superior flexure of the duodenum or immediately below it. Mucchi and Martinet[11] of Milan in 1939 reported having made the roentgen diagnosis of extrabulbar lesions in 32 of 421 cases of duodenal ulcer. Nineteen (4.5 per cent) were in the distal end of the first portion, 12 (2.9 per cent) were above the ampulla in the second portion. All of these cases were surgically explored, and these authors emphasized that there is a wide variation in the location as determined by direct exploration when compared to the roentgen localization.

It appears that the most frequent location of ulcers beyond the cap based on both surgical and roentgen reports is the region of the junction of the first and second portions of the duodenum on the inner border adjacent to the pancreas. Duodenal induration and spasm together with penetration and fixation of the ulcer bed to the pancreas with production of a relatively large inflammatory mass are prominent pathologic features. In the more distal descending duodenum, ulcers have been demonstrated much less frequently, and while the location may be as low as the ampulla of Vater, the roentgen diagnosis of lesions at this level is exceedingly rare.

The infrequency of roentgen diagnosis of ulcers beyond the first portion of the duodenum as compared to their actual incidence may be related in part to the failure of the roentgenologist to conduct a thorough survey of this somewhat inaccessible region as well as to his failure to consider the possibility of the occurrence of ulceration at this particular level of the bowel. In certain instances ulcers of the descending duodenum may have been considered simple diverticula. Especially is this true in the concavity of the duodenum, since diverticula commonly occur in this particular area. Ulcer craters located in the medial wall of

the upper descending duodenum may also have been interpreted either as barium retained in the lateral recess of a deformed duodenal cap or possibly as an ulcer crater in the cap itself (Fig. 9, 10, 11, 12 and 13).

ROENTGEN DIAGNOSIS

The roentgen diagnosis of ulcer in the descending duodenum is often made with difficulty and is frequently open to question. It requires both careful roentgenoscopic and roentgenographic study as well as consideration of the history and clinical findings. Because the possibilities to be considered in the roentgen differential diagnosis are more inclusive, these lesions require greater diagnostic deliberation than do ulcerations in the stomach or cap. The differential diagnosis concerns itself primarily with four possibilities: (1) diverticula, (2) cancer, (3) visualized ampulla of Vater, and (4) duodenitis.

Simple diverticula are seldom the source of diagnostic difficulty to the roentgenologist. Certain characteristics of the diverticulum itself usually eliminate other considerations. These features are: the smooth round or ovoid shape, the presence of mucosal folds in the stalk, the mobility and absence of tenderness, the size (average 3 cm. in diameter), the tendency to retain barium, the multiplicity (40 per cent), the location (50 per cent peri-ampullary) and the absence of mucosal pattern distortion or spasm in the adjacent duodenum. An incidence of 2.4 per cent in cases having had gastrointestinal roentgen studies has been reported. *Inflammatory traction diverticula* offer greater difficulty in differentiation. From a purely roentgenologic standpoint the possibility of acute ulceration cannot always be excluded. The multiplicity and usual location on the outer margin of the junction of the first and second portions of the duodenum are the most important differential aids in diagnosis. *Solitary pseudodiverticula* secondary to healed ulceration of the cap may simulate an ulcer of the descending duodenum. This deformity is, however, usually limited to the cap and does not produce secondary changes in the descending duodenum such as are frequently present in ulcer.

Cancerous lesions tend to encircle the duodenum, obliterate the mucosal folds, produce rigidity, fixation and often an extensive filling defect. They are peri-ampullary in from 60 to 70 per cent of cases. Primary cancer of the duodenum occurs in only 0.03 per cent of all cases, according to general necropsy statistics.[15]

Filling of the ampulla of Vater which may occur in association with chronic inflammatory disease of the pancreas is characterized by its relatively small (average 8 mm.) size and short tubular or biloculated shape, the rapid evacuation and failure to retain barium, and the location which is always slightly below the center of the descending duodenum on the medial border. Ampullary filling occurs very rarely, Lindblom[9] having observed this filling in 4 of 4,000 cases having had roentgen examination (0.1 per cent).

Primary duodenitis as has been described by Kirklin[8] and Sussman[17] may not be distinguishable from the inflammatory changes associated with acute peptic ulceration or from the residual changes following healing of the ulcer. Probably the outstanding features of duodenitis are the diffuse irritability and spasm and the distorted mucous membrane pattern without evidence of localized ulceration.

Very little mention of the roentgenographic features of ulcer in or beyond the distal portion of the duodenal cap has appeared in the literature to date. Robinson's[14] description appears to be the most complete. According to this author, the extreme distal portion of the first segment of the duodenum is the most frequent site, and in this location deep ulceration with considerable scarring and deformity is characteristic. Those lesions occurring in the pars descendens most frequently occur in the upper portion just beyond the knee on the outer and posterior margin. In this particular region a filling defect produced by scar tissue invagination of the ulcer bed rather

than a penetrating crater or niche is more characteristic. This feature of a filling defect rather than a niche as well as the tendency toward localization on the outer and posterior margin of the upper descending duodenum has not been mentioned by foreign investigators, who emphasize the importance of the niche and the tendency to localization on the inner and posterior aspect of the upper portion of the pars descendens.

In our experience, it occasionally has been difficult to determine whether a lesion involves the distal end of the cap or the upper descending duodenum. The anatomic position of the duodenum does not always conform to textbook descriptions and at times the duodenal cap is directed caudally. In these instances lesions physiologically in the distal cap itself may appear anatomically to be located in the descending or second portion. However, the dividing line between the first and second portions of the duodenum may often be determined by noting the first transverse mucous membrane folds (valvulae conniventes) which mark the beginning of the descending duodenum (Fig. 6). A lesion distal to these first transverse folds may be considered as involving the descending duodenum and is definitely distal to the cap. Even when the exact location of the crater is still in doubt the inflammatory changes in the mucous membrane plus the medial retraction of the descending duodenum may give the final clue, this deformity often permitting localization of the ulcer to the descending duodenum (Fig. 10, 11, 12, 13 and 14).

In the cases herein reported those lesions involving the descending duodenum have been noted on the upper and inner margin. Detection of the niche has been the important factor in establishing the diagnosis of active ulceration. The secondary inflammatory signs have been relatively localized to the region of the crater and are much the same as occur in association with ulcers at higher levels. Repeated examinations following medical treatment have been of value since regression or closure of the crater as well as residual changes in the mucosa or in the size of the lumen may then be noted.

CLINICAL CHARACTERISTICS

A brief review of the reported clinical features is of interest. Probably the outstanding point of interest is the tendency of these ulcers to bleed easily and profusely whereas pain appears to be a relatively minor factor. This picture has been repeatedly emphasized in the literature particularly by Wolke[19] and Brule, *et al.*[2] In 66 per cent of Wolke's cases, macroscopic bleeding was present compared to incidences of 19.5 and 25 per cent as reported by other authors[1,5] for the usual duodenal ulcer. In 50 per cent of Wolke's[19] cases hematemesis, or melana, occurred without pain. This tendency to painless hemorrhage has been attributed to the high degree of vascularity of the surrounding area of induration and the relatively deep penetration of the ulcer that may occur with relative freedom from pain. Large zones of richly vascularized tissue surrounding these ulcers have been repeatedly reported in the literature. Wolke[19] has suggested the rich vascular supply of the superior pancreatic-duodenal artery as the source of hemorrhage. Nocturnal pain has been mentioned in certain instances as occurring frequently; irregular rather than rhythmic pain appears to predominate. The scarring of ulcers situated low in the descending duodenum may involve the orifices of the common or pancreatic ducts, producing signs of obstructive jaundice or pancreatic obstruction the etiology of which may be confusing. The picture of chronic cholecystitis or of cancer of the pancreas or common duct may be suggested. A deeply penetrating ulcer may erode the common duct, resulting in a fistula between the duodenum and biliary tract. A more common complication of ulcers of the descending portion is stenosis which may produce symptoms similar to those of pyloric obstruction.

Because of the proximity and frequent fixation to the pancreas, and the usual pres-

FIG. 2. Case 1. Ulcer crater, upper and medial border of the descending duodenum with spasm and mucosal changes in adjacent descending duodenum.

ence of a large paraduodenal inflammatory mass, surgical procedures are particularly hazardous and are largely limited to gastroenterostomy alone or gastrectomy with closure of the duodenum above the ulcer.

CASE REPORTS

The following 7 cases are presented as typical examples of acute ulceration involving the region of the upper portion of the descending duodenum. These cases have been observed within a period of four years. Judging from the number of reported cases in the American literature, it may be suggested that duodenal ulceration in this particular location is not diagnosed by roentgen examination in its proper proportion. For this reason these cases are considered to be of unusual interest.

CASE 1 (No. 5232). Male, aged sixty-four. Patient gave a vague description of having had "stomach trouble" at the age of twenty-two and also at the age of forty-four. A gastric hemorrhage with vomiting occurred at the age of fifty-eight. No mention of pain was made by patient. Relief was obtained from dietary management. There was a recurrence of the hemorrhage at the age of sixty. Patient was symptom free until the age of sixty-four (1939) at which time epigastric pain was experienced. Nocturnal pain was recorded in the history as an unusually prominent symptom. After a period of one year in which dietary management was ineffective, patient submitted to a roentgenologic gastrointestinal examination.

Roentgen Examination.—November, 1939. A definite ulcer crater was demonstrated in the upper and medial portion of the descending duodenum with an incisura opposite the crater (Fig. 2 and 3). The adjacent duodenum also showed an associated inflammatory reaction. There was no retention.

Patient responded favorably to medical treatment.

When last seen in December, 1939, patient was free of symptoms.

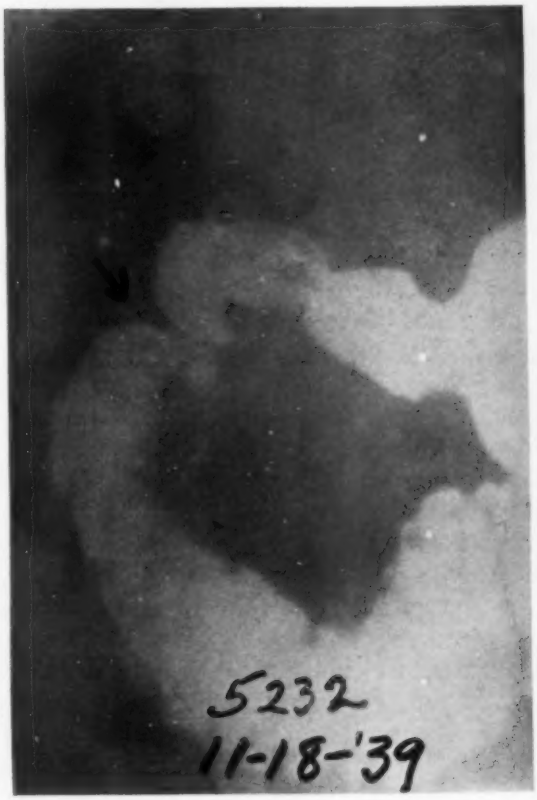


FIG. 3. Case 1. Incisura opposite site of crater.

Comment. The presence of the crater, as well as the secondary signs of ulceration (incisura, spasm, mucosal distortion), makes the diagnosis of active ulceration quite certain. Whether the crater is actually in the upper descending duodenum or in the extreme distal end of the cap may be open to argument. The relation of the first to the second portion of the duodenum is such that the usual anatomic pattern of the duodenal loop cannot be followed. The location of the crater at an unusual distance from the pylorus is quite definite.

Case II (No. 1330). L. R., male, aged thirty-eight, suffering from severe mitral valvular disease.

In January, 1931, the chief complaint was "gas on stomach" of three to four months' duration. A gnawing epigastric pain was noted five to six hours after eating, and the patient was frequently awakened at night with epigastric pain.

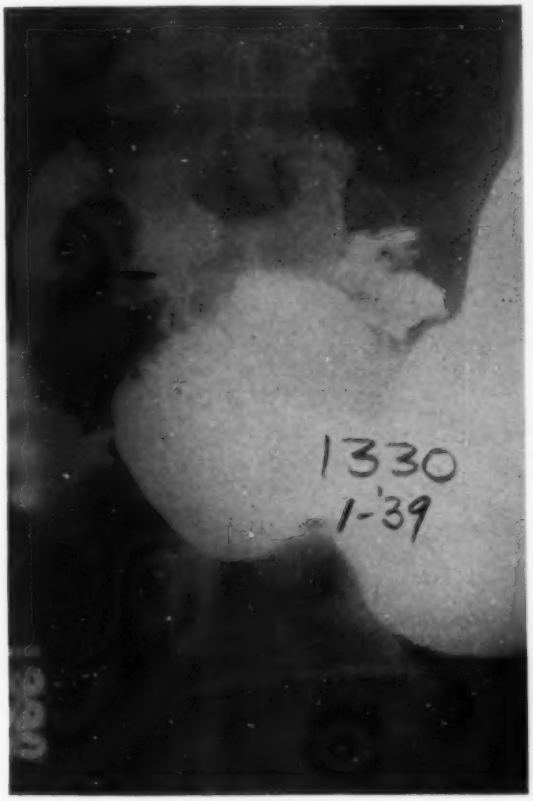


Fig. 4. Case II. Ulcer crater, upper and medial margin of the descending duodenum with spasm and mucosal change in adjacent duodenum.

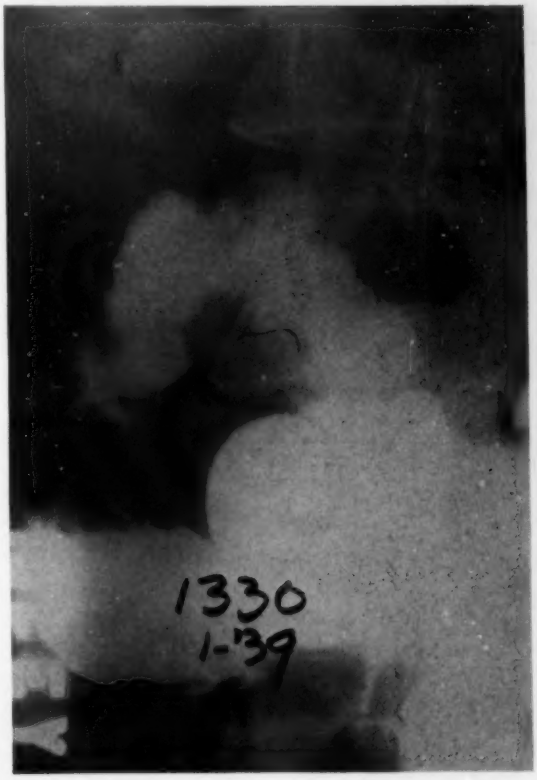


Fig. 5. Case II. Incisura opposite site of crater, and inflammatory mucosal changes in adjacent duodenum.

Roentgen Examination.—January, 1939. There was evidence of an ulcer on the medial side of the upper descending duodenum with evidence of inflammatory reaction and an incisura was also present (Fig. 4 and 5). The crater resembled somewhat a diverticulum but was more suggestive of an ulcer. There was no retention.

After being placed on an ulcer diet, patient stated he obtained satisfactory relief for a period of three months. Later, after not adhering to his diet, "gas on the stomach" was again reported as the chief complaint. The patient had a fibrillation upon his second admission. There was no evidence of bleeding in the intestinal tract.

A roentgen examination in April, 1940 (Fig. 6) showed residual minimal deformity from duodenitis and healed duodenal ulcer. Diverticulum of second portion of duodenum. Evi-

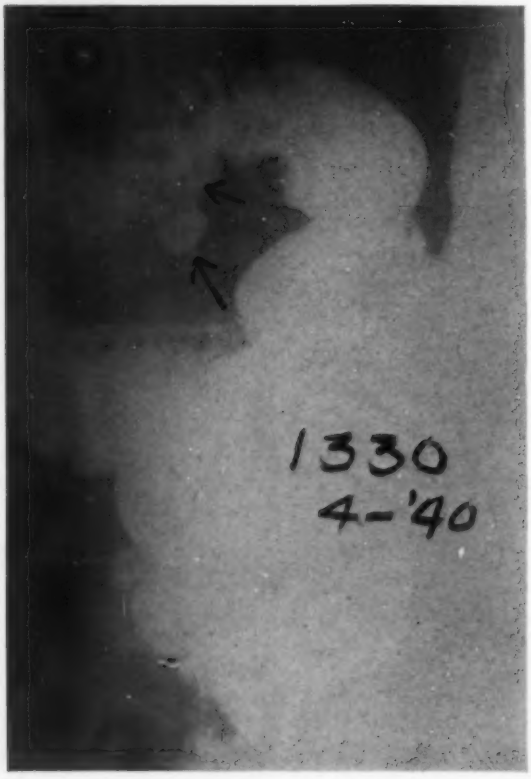


Fig. 6. Case II. Diverticulum near site of previous ulcer crater. Note mucosal folds in neck, relatively large size, smooth outline and suggestion of scar tissue indentation immediately distal. Transverse mucosal folds originate proximally indicating beginning of descending duodenum.

dence of an open ulceration could not be demonstrated.

Since the findings strongly indicated acute ulceration in January, 1939 (crater, incisura, mucosal changes) and fifteen months later suggested the presence of a diverticulum (mucosal folds in neck, size, shape), it seems probable that in this instance the diverticulum formation is associated with the ulcer healing.

Comment. In this instance the crater is quite clearly situated in the upper descending duodenum. The first and second portions of the duodenum follow more closely the usual textbook description. From Figure 6 it is apparent that the crater was located well beyond the beginning of the valvulae conniventes. The inflammatory changes present in Figures 4 and 5 are not present in Figure 6, further indicating that the original ulcer has healed and that a diverticulum formation has resulted.

Case III* (No. 661081). Male, aged fifty-eight. For twenty years patient had had recurrent, seasonal episodes of gastric distress relived by food or alkaline medication.

In August, 1939, there was passage of gross blood by stool followed by hematemesis. There was progressive weakness, vertigo, and repeated hemorrhage without mention of pain. Upon admission to hospital, the patient was in a state of impending shock secondary to hemorrhage. Hemoglobin was 25 per cent and stool examinations were positive for blood. Fourteen transfusions on successive days were necessary to maintain satisfactory hemoglobin level.

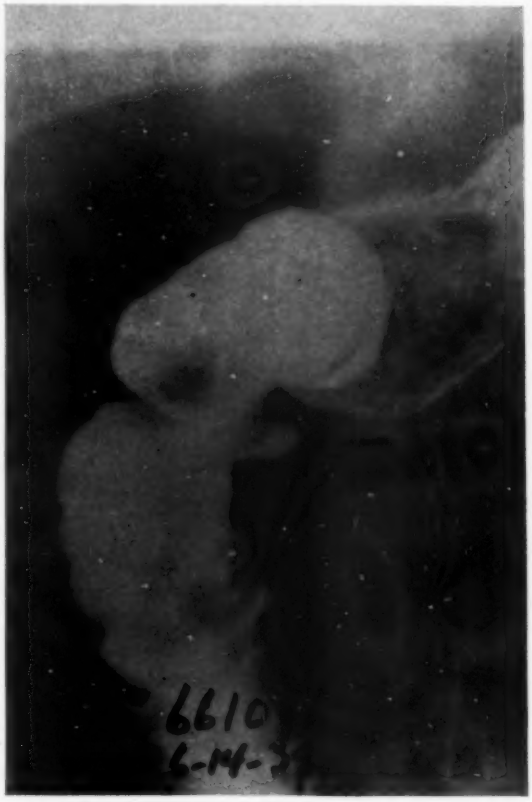


Fig. 7. Case III. Ulcer crater, upper and medial margin of the descending duodenum with incisura opposite. Associated inflammatory swelling of mucosal folds and rigidity of walls.

* Presented through the courtesy of Dr. L. G. Rigler, Department of Radiology, University of Minnesota Hospitals, Minneapolis.

Roentgen Examination.—September 15, 1937. Duodenal cap deformity; no evidence of open ulceration.

Patient discharged and remained well until June, 1938, when he was re-admitted after having had gross hemorrhage from the bowel. Hemoglobin was 47 per cent. Conservative treatment was again successful. Discharged July 5, 1938.

Roentgen Examination.—October, 1938. Healed ulcer of distal duodenal cap. Patient was re-admitted for the third time in June, 1939, with typical ulcer symptoms. Stool examination was positive for occult blood.

Roentgen Examination.—June 14, 1939. A large ulcer crater was demonstrated projecting from the medial wall of the upper descending duodenum, apparently penetrating the region of the pancreas (Fig. 7). There was infiltration and rigidity surrounding the crater suggesting the presence of a mass. Three possibilities were suggested: (1) benign ulcer with penetration into the pancreas with inflammatory induration; (2) cancer of the pancreas or duodenum with ulceration; (3) benign tumor of pancreas which had become secondarily ulcerated. Medical treatment again instituted and was successful.

Roentgen Examination.—July 17, 1939. No evidence of crater but incisura still present (Fig. 8). Improvement continued, and patient was discharged on August 2, 1939. Gross hemorrhage from the intestinal tract again noted on September 10, 1939. Re-admitted September 14, 1939, with persistent bleeding. Hemoglobin 62 per cent and on September 18 hemoglobin level had dropped to 39 per cent.

Surgery.—September 18, 1939. No perforation was found. This was the first bleeding duodenal ulcer having had emergency operation in which perforation was not found.* Extensive ulceration of the duodenum was present, and it was felt that the source of bleeding was from the gastroduodenal artery within the duodenal wall. A subtotal gastric resection was done, and the duodenum was inverted after resecting as much of the duodenum as possible. Postoperative course was satisfactory. Patient was discharged on October 1, 1939, and on October 1, 1940, there had been no recurrence of symptoms.

Comment. The history of repeated and severe hemorrhage, together with the unusual location and deep penetration of the crater, is of interest. The vascular supply in this particular area is probably more profuse than in the case of the usual duodenal ulcer and may account for the unusual degree of hemorrhage. Paraduodenal inflammatory masses are important signs of ulceration in this location.

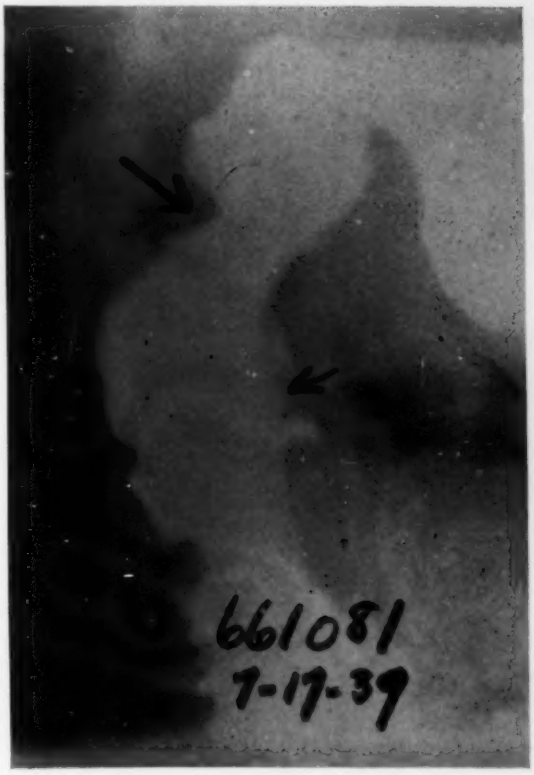


Fig. 8. Case III. Incisura opposite site of crater which has now disappeared. Mucosal changes in descending duodenum still apparent.

Case IV† (No. 8451). J. A., male, aged fifty-eight. Patient's admitting complaint was pain in the epigastrum of one and one-half years' duration, radiating to the left upper quadrant and occasionally down the midline to the region of the penis or into the back. The pain was more troublesome at night. There was transitory relief from repeated doses of alkali. For a week previous to the present admission, nausea and vomiting of bile had occurred, and gaseous eructations followed ingestion of fatty foods. During

* From the records of the University of Minnesota Hospitals, Minneapolis.

† Presented through the courtesy of Dr. O. Lipschultz, Roentgenologist, Minneapolis General Hospital, Minneapolis.

Fig. 9. Case IV. Ulcer crater, upper and medial margin of the descending duodenum with incisura opposite. Slight inflammatory narrowing of lumen.

the past two days black stools were noted. Stool examination showed a four plus benzidine reaction.

Roentgen Examination.—May 19, 1940. A large pocket of barium was noted on the upper and inner margin of the second portion of the duodenum which was thought to represent an ulcer crater (Fig. 9). Because of the size of this pocket of barium, the possibility of a primary cancerous ulcer or of an ulcer secondary to an extrinsic tumor was considered.

Surgery. A large firm mass was found involving the inner side of the second portion of the duodenum which was covered with dense scar tissue. There was a definite inflammatory reaction with considerable edema of the adjacent structures and bowel wall. The impression was a penetrating duodenal ulcer, secondarily involving the pancreas. Because of the extreme inflammatory changes, a gastric resection was deemed inadvisable, and a posterior gastrojejunostomy was performed.

Patient was discharged improved.

Comment. A highly vascularized and indurated mass involving the descending duodenum adjacent to the ulcer is again the prominent pathologic feature in this case. From the roentgen standpoint, the findings are similar to those in Case III.

Case V (No. 695526). Male, aged seventy. In 1937, this case had been diagnosed elsewhere as chronic duodenal ulcer (roentgen examination). Epigastric pain relieved by food and occurring frequently during the night was the prominent feature of the previous history. Symptoms were controlled satisfactorily, after some delay, by diet and alkaline medication. In May, 1940, patient was hospitalized after having experienced a gradual return of epigastric pain especially severe at night, anorexia, progressive weakness and spells of vertigo. Relief could not be obtained from alkalis. Tarry stools had been noted and the patient was pale and had fainted upon attempts to arise. Hemoglobin was 55 per cent and stools were positive for blood.

Roentgen Examination.—June 4, 1940. Crater was demonstrated on the medial border of the upper descending duodenum with considerable deformity and evidence of retraction of the upper descending duodenum and crater toward

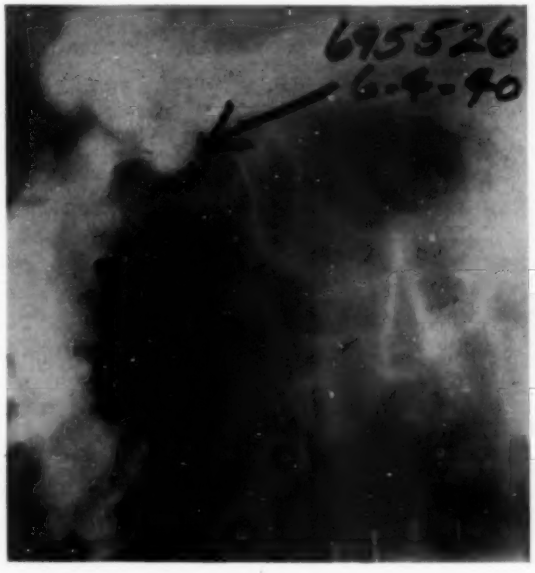


Fig. 10. Case V. Ulcer crater (large arrow) retracted upward and medially, its position simulating that of lateral recess of a deformed duodenal cap. Note changes in mucosal fold pattern of descending duodenum (small arrow).

the inferior margin of the duodenal cap. The appearance was somewhat suggestive of a duodenal cap ulcer located in the lateral recess (Fig. 10 and 11).

Response to strict medical management was satisfactory.

In January, 1941, the patient was re-admitted with a history of recurring epigastric distress but without evidence of hemorrhage. Medical management was again instituted. Shortly after discharge from the hospital (February 15, 1941) epigastric pain increased in severity and was unusually prominent during the night. Milk or cream had to be taken as often as six to eight times during the night to relieve pain. Rigid dietary and medical management had been strictly adhered to by the patient.

Roentgen Examination.—May 15, 1941. Large crater was demonstrated in the same location as on the previous examination. There again was retraction of the crater medially and considerable deformity of the adjacent descending duodenum, the lumen of which was greatly narrowed (Fig. 12). There was tenderness upon palpation directly over the region of the crater.

Fig. 11. Case v. Ulcer crater position again suggests deformed lateral recess of cap (large arrow). Spasm of descending duodenum and distorted position of upper descending duodenum (small arrows).

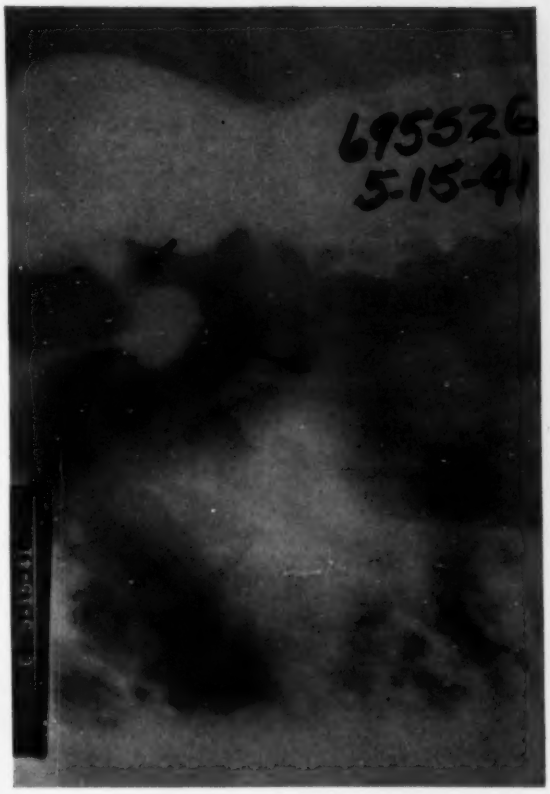


Fig. 12. Case v. Relatively large crater, showing unusual medial retraction (large arrow) and narrowed lumen of duodenum above and below crater (small arrows).

Medical treatment was again instituted.

Comment. Recurrent severe epigastric pain, predominantly nocturnal, with periodic hemorrhage at one time resulting in a definite secondary anemia, was the clinical feature of interest. From the roentgen standpoint the location of the crater is of interest because of the possibilities for error in localization. Certain of the roentgenograms of the study dated June 4, 1940 are even more deceptive than those herein reproduced (Fig. 10 and 11) and might easily have been interpreted from film study alone as an ulcer crater or as a pseudodiverticulum of the cap. Inflammatory changes in the descending duodenum secondary to the ulceration are of value in localization.

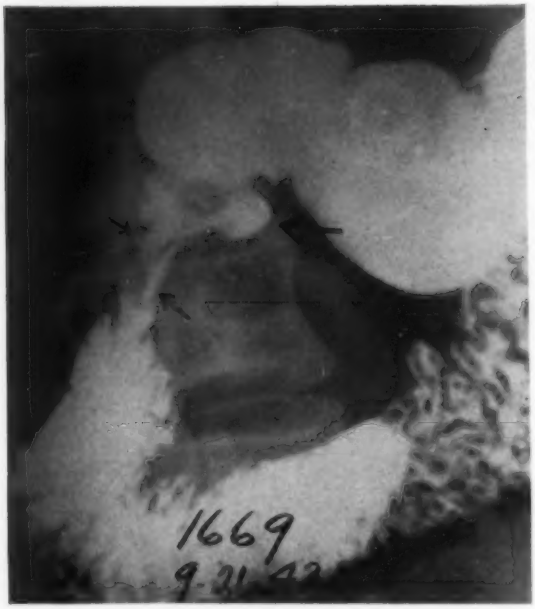


FIG. 13. Case VI. Note similarity of ulcer crater (large arrow) to pseudodiverticulum of cap. Mucosal changes, spasm and medial retraction of the upper descending duodenum (small arrows) indicate origin of crater.

CASE VI* (No. 1669). R. F., male, aged thirty-five. For the past ten years this patient had had symptoms quite typical of duodenal ulcer. The first severe episode was accompanied by vomiting of blood but medical management resulted in improvement. A subsequent roentgen examination was said to have revealed evidence of a duodenal ulcer, the location of which was not specified. Since that time there have been occasional mild attacks and one severe attack of epigastric pain and distress with relief from medication. The present symptoms included persistent and unusually severe epigastric pain and tenderness with nausea and vomiting.

Roentgen Examination.—September 21, 1942. A fairly large penetrating type of ulcer crater was demonstrated just below the superior flexure of the duodenum. There was considerable spasm and mucosal fold distortion in the adjacent descending duodenum (Fig. 13).

On September 25, 1942, the patient attempted, against advice, to return to work following which epigastric pain recurred and relief from the usual medications was ineffective. Opiates were required for relief of pain and stool examinations were positive for blood. The clinical picture became that of a severe hemorrhage from the gastrointestinal tract. Hemoglobin dropped to 29 per cent in spite of three daily blood transfusions.

Surgery.—October 6, 1942. The location of the bleeding could not be determined by inspection. The duodenum was therefore opened and no ulcer could be seen in the superior duodenum. The crater was located by palpation in the inner wall of the descending duodenum definitely below the superior flexure. A small clot was present in the crater and later active arterial bleeding from the ulcer was visible, apparently originating from the branches of the superior pancreatic-duodenal artery. Penetration of the pancreas had occurred. The duodenum was sectioned just distal to the pylorus and about one-half of the stomach was resected. An anterior gastrojejunostomy was performed.

On December 15, 1942, the patient returned to work, hemoglobin 85 per cent, condition satisfactory.

Comment. The outstanding clinical features were unusually severe pain and later profuse and persistent hemorrhage. Previous to the present episode the symptom complex and clinical course had been fairly typical of the usual type of duodenal ulcer.

FIG. 14. Case VII. Location of crater (large arrow) and secondary changes in descending duodenum (small arrow) similar to Case VI.

* Presented through the courtesy of Dr. J. K. Moen, Minneapolis.

Roentgenograms made a number of years previously were reviewed and the location of the ulcer crater was the same as at the present time. The crater had, however, been considered a pseudodiverticulum of the lateral recess of the duodenal cap.

Case VII (No. 3626). J. C., male, aged seventy-two. For twenty years this patient had had seasonal episodes of epigastric distress, always relieved by alkaline medication and a bland diet. For a few months prior to the present hospital admission, patient had noted unusual upper abdominal pain, described as rather vague but persistent. On January 10, 1943, there was epigastric pain followed shortly by repeated bowel movements with tarry stools.

Roentgen Examination—January 22, 1943. A moderate sized ulcer crater was demonstrated at the superior flexure on the inner side of the duodenum with secondary spasm, retraction and mucous membrane distortion in the adjacent descending duodenum (Fig. 14).

Laboratory examinations of the stools were repeatedly positive for blood.

Upon discharge from the hospital, February 9, 1943, after having received routine ulcer management, patient was free of pain, and stool examinations for blood were negative.

SUMMARY

(1) Seven cases of active ulcer in the upper descending duodenum, all demonstrated by roentgen examination, are reported. In three instances the location of the crater has been confirmed by surgical inspection.

(2) In all seven cases the location of the crater was on the upper and inner margin of the descending duodenum usually just below the superior flexure.

(3) Secondary spasm, mucosal distortion and medial retraction of the adjacent upper descending duodenum have been present in every case.

(4) Macroscopic hemorrhage was a prominent feature in six of the seven cases; in three instances the degree of blood loss was unusually severe. Nocturnal pain was prominent in four of the seven cases.

CONCLUSIONS

(1) Peptic ulcer occurs infrequently in the descending duodenum; roentgen diagnosis of these ulcers based on reported cases is made even less frequently.

(2) Failure of the roentgenologist to thoroughly explore this particular area of the duodenum together with confusion with the more commonly occurring simple and pseudodiverticula accounts, in part, for the discrepancy.

(3) The typical location of the ulcer craters in this series has been in the upper and inner wall near the superior duodenal flexure; penetration of the pancreas and secondary spasm, fixation and medial retraction of the upper descending duodenum are frequent findings.

(4) Gross hemorrhage, often severe, is frequently associated with ulceration in the descending duodenum.

802 Medical Arts Building
Minneapolis, Minnesota

REFERENCES

1. Balfour, D. C. Collected Papers of the Mayo Clinic, 1922, *13*, 52–68.
2. Brule, M., Hillemand, P., Gilbrin, E., and Callandry, L. L'ulcère de la deuxième portion du duodénum. *Arch. d. mal. de l'app. digestif*, 1939, *29*, 846–855.
3. Case, J. T. Roentgen observations on the duodenum with special reference to lesions beyond the first portion. Am. J. Roentgenol., 1916, *3*, 314–326.
4. Crane, A. W. Behavior of the stomach in ulcer and cancer of the duodenum below the bulb. Am. J. Roentgenol., 1922, *9*, 102–111.
5. Crohn, B. B. Affections of the Stomach. W. B. Saunders Co., Philadelphia, 1927, pp. 619–620.
6. Demirleau, J. Les ulcères de la deuxième portion du duodénum. *Arch. d. mal de l'app. digestif*, 1939, *29*, 856–864.
7. Judd, E. S. Pathologic conditions of the duodenum. *Journal-Lancet*, 1921, *41*, 215–220.
8. Kirklin, B. R. Duodenitis and its roentgenologic characteristics. Am. J. Roentgenol. & Rad. Therapy, 1934, *31*, 581–587.
9. Lindblom, A. F. Des altérations roentgenologiques de l'estomac et du duodénum dans les pancréatites. *Acta radiol.*, 1928, *9*, 255–265.
10. Moynihan, B. G. A. Duodenal Ulcer. W. B. Saunders Co., Philadelphia, p. 264.

11. MUCCHI, L., and MARTINET, R. L'ulcera dell'estremo distale della I porzione dell duodeno e l'ulcera duodenale extrabulbare. *Radiol. med.*, 1939, *26*, 289–305.
12. PERRY and SHAW. Quoted by Moynihan.[10]
13. PORTIS, S. A., and JAFFE, R. H. Study of peptic ulcer based on necropsy records. *J. Am. M. Ass.*, 1938, *110*, 6–13.
14. ROBINSON, W. W. Extra-bulbar or duodenal ulcer. *South. M. J.*, 1934, *27*, 759–763.
15. STARTZ, I. S. Duodenal carcinoma: its relationship to duodenal ulcer. *Radiology*, 1935, *25*, 688–697.
16. STURTEVANT, M., and SHAPIRO, L. L. Gastric and duodenal ulcer. *Arch. Int. Med.*, 1926, *38*, 41–56.
17. SUSSMAN, M. L. Inflammation of descending portion of duodenum. *Radiology*, 1935, *24*, 691.
18. WEINTRAUB, S., and TUGGLE, A. Duodenal diverticula. *Radiology*, 1941, *36*, 297–301.
19. WOLKE, K. Ueber Ulzera in der Pars descendens duodeni. *Acta radiol.*, 1936, *17*, 371–387.

GAUCHER'S DISEASE

By SAMUEL LEVINE, M.D., *and* LEON SOLIS-COHEN, M.D.
Jewish Hospital
PHILADELPHIA, PENNSYLVANIA

IN 1882 Gaucher described the disease, named after him, as a primary epithelioma of the spleen. The neoplastic nature of the condition was disputed by Bovaird of New York in 1900. It was Mandelbaum and Downey who in 1916 founded the modern conception of the disease as a metabolic disturbance. It remained for the chemists, Lieb and Epstein, to single out kerasin as the chief constituent of the Gaucher cells.[4] The disease is a familial, congenital condition preponderant in females, characterized by gradual splenohepatomegaly and prominent bony roentgenologic changes. There is a purely osseous type in which there is neither splenic nor hepatic enlargement. Our second case exemplifies this type.

Hemorrhagic diathesis is a late complication of the disease due to developing thrombocytopenia; this necessitates a splenectomy. In removing the spleen it is necessary also to remove accessory spleens, if found, as these may take on the function of the spleen, perpetuating the thrombocytopenia even after splenectomy.

Pick divides xanthomatosis into (1) secondary symptomatic types, and (2) primary essential forms. The former occur as multiple, flat, yellowish, cutaneous deposits in diabetes insipidus and in hepatic disease. They are usually associated with a cholesteremia. The spleen, hematopoietic system, and the suprarenal cortex may contain an excess of the lipoid material.

Primary xanthomatoses are in turn subdivided by Pick into (1) Gaucher's disease. The principle constituent of the foam cells is kerasin, a cerebroside substance which stains light blue with Mallory's stain, with acid fuchsin, with previous fixation with picric acid and ammonium bichromate. (2) Niemann-Pick's disease described in 1914: a phosphatid disturbance, overwhelming and of short duration attacking young children and involving the reticuloendothelial system. Dyspnea and cyanosis are marked and splenohepatomegaly are pronounced. (3) Hand-Schüller-Christian's disease, originally described by Hand in 1893, due to deposition of cholesterol and its esters in the reticulo-endothelial system, and characterized by defects especially in flat bones. Polyuria, exopthalmos and diabetes insipidus are also present. (4) Primary non-symptomatic internal and external xanthomatosis.

CASE 1. B. M., aged twenty-nine, a white female in good health, slipped on a raft on June 16, 1935, and hit her left elbow, fracturing the left humerus. She was examined by us on July 25, 1935.

The previous personal history was essentially negative. Her physical condition at the time was normal. She now presented no symptomatology. The family history was negative.

Laboratory Findings. Examination of the blood made on July 26, 1935 showed a hemoglobin of 78 per cent; an erythrocyte count of 3,850,000; leukocytes 6,100, with 62 per cent neutrophiles, 35 per cent lymphocytes, and 3 per cent eosinophiles. The specific gravity of the urine was 1.005 to 1.009. Basal metabolic rate, plus 1 per cent. Blood sugar, 75 mg., blood urea, 10 mg., blood cholesterol, 147 mg., blood calcium, 10 mg., blood phosphorus, 4.7 mg., Bence-Jones protein, negative.

From all the laboratory studies made, no certain diagnosis could be established so the patient was readmitted for a bone biopsy from her right humerus on September 15, 1935. This revealed the following: "The section of the marrow shows a number of large polygonal cells having an alveolar arrangement. These contain prominent, irregularly shaped nuclei. The cellular cytoplasm is acidophilic and is stippled in appearance. Under oil immersion the cells present a fibrillar, wrinkled appearance. The section shows clusters of large cells invading haversian canals. Very few vacuolated areas are seen in the cytoplasm. Some of the cells show evidence of compression. The bone marrow contains large numbers of myeloblasts, promyelocytes, and very few mega-

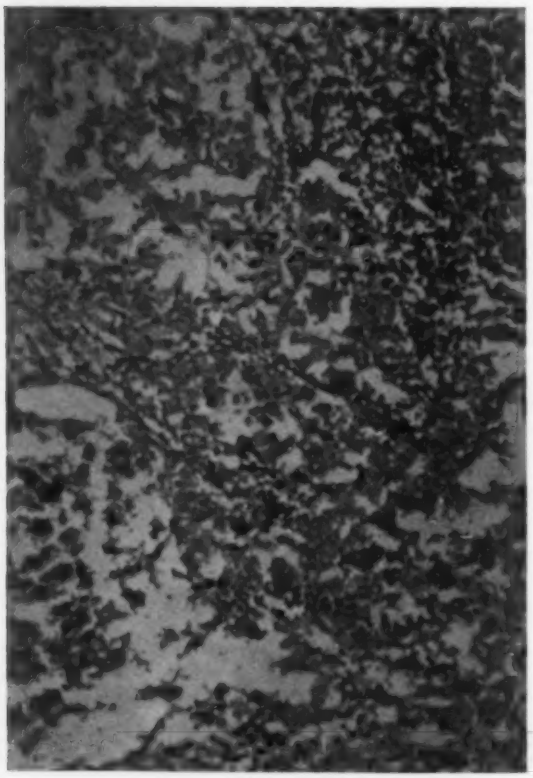


FIG. 1. Case 1. Note numerous Gaucher cells arranged in alveolar formation. Nuclei are eccentric and prominent. Cytoplasm of cells is acidophilic.

karyocytes are observed. Large numbers of normoblasts and occasional macroblasts are present. Small numbers of young polymorphonuclears are also noted (Fig. 1 and 2).

FIG. 2. Case 1. Nuclei are homogeneous in size and appearance. Occasional binucleated cells are seen.

FIG. 3. Case 1. Note numerous punched out areas in humerus due to infiltration with Gaucher cells. There is a large subperiosteal defect in upper end of humerus.

"The cells are dull hyalin and homogeneous in texture. They measure 20–80μ. Most of the cells contain one nucleus; however, some are binucleated. Some of the cells are arranged in isolated nests and others appear as large, confluent, poorly demarcated foci. A large proportion of the cells are elongated due to compression.

"*Diagnosis:* The large cells described above are Gaucher cells."

Xanthomatosis was suspected in this case, but the character and the distribution of the bony lesions were not typical and we could only prove our diagnosis through bone biopsy. The changes in each humerus were identical and symmetrical. Small multiple areas of punctate osteolysis were symmetrically distributed throughout the cortical and medullary portions of the shaft. At the neck of the humerus, the cortex and periosteum showed early destruction. The right tibia, right radius, left femur, and hands showed isolated osteolytic areas, widening of the medullary canal, and bone sclerosis in various portions of the shaft, and the absorption of bony trabeculae at the diaphyseal ends of the bones. An Erlenmeyer flask appearance was absent at the lower ends of the femora. The skull showed minute areas of bone lysis in the frontal and parietal bones. There

Fig. 4. Case II. Erlenmeyer flask deformity with marked tapering of the femoral shafts. Lower ends of femora are convex and lack usual flanging out epicondyles.

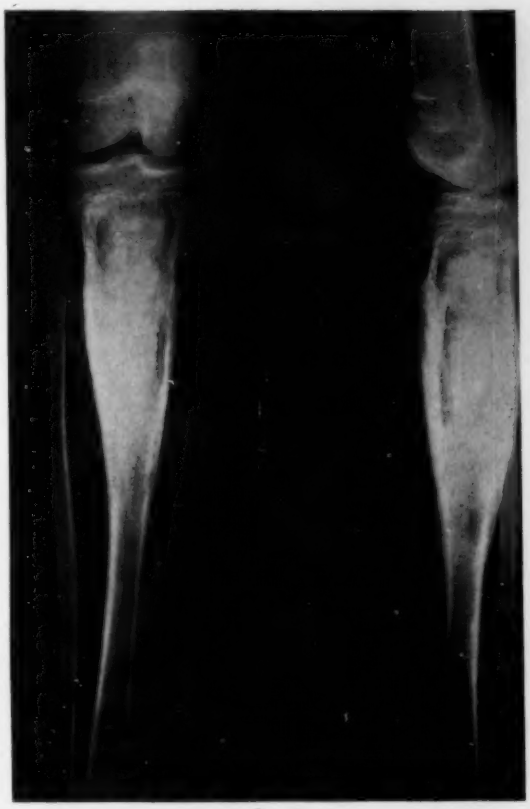


Fig. 5. Case II. Condensation of tibia and areas of radiolucency are due to chronic osteomyelitis produced by operation on bone affected with Gaucher's disease.

was no thinning or thickening of the tables of the skull. The mandible revealed osteoporosis and lipoid deposits in the region of the lower bicuspid teeth incidental to Gaucher's disease. Exclusive of the latter finding, and in view of the absence of splenic enlargement, and in the absence of typical blood and blood chemistry findings, we did not feel that Gaucher's disease could be proved without bone biopsy. Differential diagnosis, which we had to consider, included multiple myeloma and metastatic sarcomatous process and osteitis fibrosa cystica (Fig. 3).

Case II. This case was reported in full by Capper, Epstein and Schless,[1] from the Pediatric Service of the Jewish Hospital. Our reason for mentioning it here is to contrast the type and course of the bone changes, and how each in a different way led first to an erroneous conclusion. Case II when it was first seen by us on January 19, 1934, had been diagnosed previously, and operated upon for osteomyelitis.

A roentgenologic diagnosis of Gaucher's disease was made on a typical Erlenmeyer flask deformity of the lower ends of both femora (Fig. 4).

Roentgen treatment was given to the long bones without results. Bone pain had become a feature and was unrelieved by therapy. In the second case, bone pain and bone destruction led to operative interference for osteomyelitis. In the second patient's report, we felt that the pain was due to lipoid deposits in the medullary canals and the bone marrow (Fig. 5).

DISCUSSION

Pick states definitely that while the cortex is coarsely trabeculated and thinned out, he has never seen perforation of the cortex near the subperiosteum (no matter how thin the shelf of cortex). Our first case is an exception to the rule. There is a definite penetration by the Gaucher cells into the subperiosteal space; the periosteum enveloped the bone like a thin sheath of parchment and a probe could be easily projected through it into the marrow cavity. The curious observation is that the changes, as seen in the photomicrograph, occur with perfect symmetry in both humeri.

Another interesting finding, hitherto not pointed out, is the characteristic appearance of the mandible. This presents numerous unilocular vacuolated spaces due to replacement of bone by Gaucher cells. The peridental membrane is not involved and no loosening of teeth or pyorrheal tendency was noted. The areas of rarefaction are sharply delineated by trabeculae and are diffusely distributed throughout the mandible. When noted on a roentgenogram it should suggest the possibility of Gaucher's disease (Fig. 6).

Splenectomy in Case II cured the bleeding diathesis and thrombocytopenia and arrested the development of a left-sided hydronephrosis due to mechanical pressure

FIG. 6. Case II. Note large vacuolated areas in the mandible due to infiltration with Gaucher cells.

Early in the course of the second case, the tibia and femur were explored erroneously because of "bone crises." This resulted in an intractable osteomyelitis which has been draining for about six years. It is well to remember that Gaucher's bone crises contraindicate surgical exploration, since prolonged draining sinuses are the inevitable result.

CONCLUSION

1. Two cases of Gaucher's disease are reported (Case II already reported elsewhere): one with typical bony changes and the other with several atypical findings.

2. Penetration into the subperiosteal space can occur in Gaucher's disease.

3. Generalized vacuolation and osteoporosis of the mandible are characteristic of Gaucher's disease.

REFERENCES

1. Capper, A., Epstein, H., and Schless, R. A. Gaucher's disease. *Am. J. M. Sc.*, 1934, *188*, 84–93.
2. Christian, H. A. Contribution to Medical and Biological Research. Paul B. Hoeber, Inc., New York, 1919, *1*, 390.
3. Epstein, E., and Lorenz, K. Die Phosphatidzellverfettung der Milz bei Niemann-Pickscher Krankheit verglichen mit der Lipoidchemie der Morbus Gaucher und der Schüller-Christianschen Krankheit. *Ztschr. f. physiol., Chem.*, 1930, *192*, 145–170.
4. Pick, L. Classification of diseases of lipoid metabolism and Gaucher's disease. *Am. J. M. Sc.*, 1933, *185*, 453–469.
5. Pick, L. Niemann-Pick's disease and other forms of so-called xanthomatosis. *Am. J. M. Sc.*, 1933, *185*, 601–616.
6. Schüller, A. Ueber eigenartige Schädeldefekte im Jugendalter. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1915–1916, *23*, 12–18.

RUPTURED LIGAMENTS OF THE ANKLE

A ROENTGEN SIGN

By ROBERT P. BALL, *Major, M. C., A.U.S., and* E. WAYNE EGBERT, *Captain, M.C., A.U.S.*

IN MOST instances a roentgen examination of the ankle following trauma is made to rule out the presence of a fracture. Information regarding an injury (rupture) of the ligaments may be disclosed in routine roentgenograms of the ankle when made in the manner to be described. A spread of the tibiofibular ankle mortise from torn ligaments may produce a permanently unstable ankle joint if dismissed as a simple "sprain." Pain and soft tissue swelling may prevent adequate clinical demonstration of a widened mortise. When the injury is severe enough to produce a widening of the ankle mortise, it should be recognized in a routine roentgen interpretation.

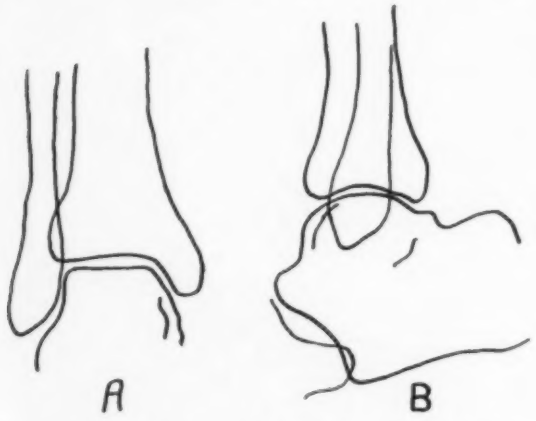


FIG. 1. Tracings of anteroposterior and lateral views of the ankle showing in *A* a translucent zone between the articulating surfaces of both malleoli and the talus. The presence of this space *on both sides* is not seen except when there is a spread of the tibiofibular ankle mortise from ruptured ligaments. The lateral view, *B*, does not contribute any information about a tibiofibular spread but is, of course, taken in the routine examination to rule out a fracture.

A spread of the ankle mortise sufficient to show a translucent zone or space between the inner margins of the articulating surfaces of both malleoli and the talus is evidence of disruption of the ligaments about the ankle joint (Fig. 1, *A*). This sign may not be present in all cases with injury to the ligaments but when found it is positive evidence of soft tissue injury of clinical significance. Any immobilizing devices such as casts, strappings, etc., which bind the ankle may prevent the sign being shown and for this reason should not be in place during the examination.

TECHNIQUE

Two views are made, one in the anteroposterior projection and one in the lateral. The first view is taken with the patient supine and the foot in normal anatomical position (Fig. 2, *A*). The foot is placed with the heel resting on the cassette or cardboard holder and sole of the foot on a vertical plane of 90 degrees to the film surface. Moderate plantar flexion or dorsiflexion of the foot will not appreciably alter the appearance of the ankle mortise (Fig. 3).

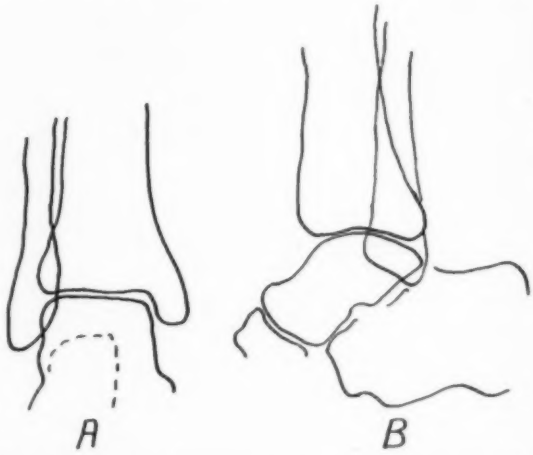


FIG. 2. Tracings of roentgenograms of a normal ankle taken in anteroposterior and lateral views. In *A* it can be seen that a translucent zone is not present on *both* sides of the talus. Compare with Figure 1, *A*.

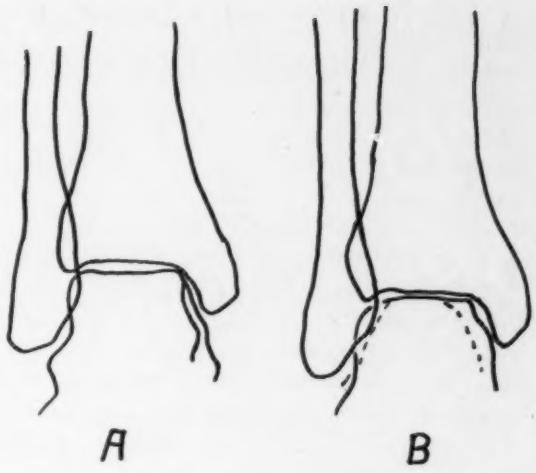


Fig. 3. Tracings from roentgenograms of the ankle in anteroposterior views with the foot in anatomical position *A* (sole of the foot in a plane 90 degrees to the long axis of the leg), and *B* in plantar flexion. Moderate dorsiflexion or plantar flexion of the foot does not appreciably change the spacing between both malleoli and talus.

However, it is essential that the foot not be rotated either laterally or medially for the true anteroposterior view. The central rays should pass through a point midway between the malleoli at the level of the joint space.

The lateral view is the standard procedure taken with the long axis of the foot parallel to the film surface. This view does not contribute information regarding the ankle mortise but is necessary for a routine examination of the ankle joint.

ABNORMAL PULMONARY PHYSIOLOGY AS A RESULT OF CHRONIC IRRADIATION PLEUROPULMONITIS*

A PRELIMINARY REPORT

By JOHN E. LEACH, M.D.
NEW YORK, NEW YORK

IN A previous paper[15] on chronic pleuropulmonitis following roentgen irradiation for cancer of the breast, attention was called to the reduction of certain measurements of pulmonary capacity. This study has been amplified and the purpose of this report is to point out some of the striking deviations from the normal pulmonary physiology that may occur in patients who sustain pulmonary fibrosis following deep roentgen therapy to tumors on or within the thorax. From these observations it is hoped that a better understanding of the mechanism of the symptoms and signs of the disease may be gained and thereby enable application of proper therapeutic measures for its relief.

The anatomical changes within the thorax following deep roentgen therapy have been described in part in previous investigations.[3,21] The main focus of interest has been on the lesions induced in the pleura and lungs, but little note has been made of the marked changes in the thoracic parietes, the mediastinum and diaphragm.

Since the majority of patients studied have been treated for breast cancer, the following remarks are descriptive of the changes observed in these treated patients, but they may be applied to other patients treated by radiation for other exothoracic or endothoracic neoplasms.

The skin and subcutaneous tissues frequently undergo some degree of atrophy and fibrosis with resultant contracture and loss of elasticity. This interferes with the increase in surface area of the chest wall that is needed in the inspiratory act. The intercostals, as well as some of the accessory respiratory muscles, may also lose muscle fibers and undergo fibrosis. This hinders normal muscle contraction and relaxation. In some instances, the skin and muscles are adherent to each other and form a shield-like structure which holds a portion of the chest in one continuous position curbing both inspiration and expiration.

Local or general irradiation osteitis probably does not hamper normal thoracic function. However, a pathological fracture of one or more ribs or the clavicle may impair thoracic motion because of pain or altered direction of muscle pull. The pleuritis, pulmonary fibrosis and even carnification of the lung have been very adequately described by various authors.[3,16,21] As a result of the pleural and pulmonary contracture the intercostal spaces become narrower, the diaphragm on the affected side ascends and the mediastinum and its contents are pulled toward the diseased side. The other lung necessarily increases its volume somewhat, i.e., develops some degree of relative emphysema.

There may also be an associated mediastinitis of a variable degree ending in some mediastinal fibrosis[14] and fixation of the hilum of the lung. This in turn prevents the normal movement of the bronchial tree downward and forward with inspiration. Instead, these structures tend to be held in their expiratory position. While the main bronchi close to the hilum seemingly escape irradiation, it is not unusual to observe atrophy, engorgement, telangiectasia and ulceration of the bronchial mucosa and even bronchial distortion and stenosis. Tenting of the diaphragm and interference

* From the Department of Medicine, Memorial Hospital, New York. Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.

with descent or fixation of the diaphragm during inspiration are very common findings. The foregoing observations have all been confirmed by physical examination, roentgenoscopy, bronchoscopy, vasography and histologic study.

One wonders at the marked change that may occur when only a portion of the thorax is irradiated. We will attempt to show that even though only a portion of the lung is exposed to deep roentgen therapy, the remaining lung may be affected by a secondary reaction ending in fibrosis, the volume of which far exceeds the volume of lung originally exposed to radiation.

In essence, then, chronic irradiation pleuropulmonitis is not merely a pleuropulmonary disorder, but it includes changes in the thoracic parietes, as well as the diaphragm and mediastinum.

SELECTION OF PATIENTS FOR STUDY

In order to determine the mechanism of pulmonary disability arising from chronic irradiation fibrosis of the lung, 17 patients with varying degrees of the disease have been studied. They were subjected to various tests of pulmonary and circulatory function. These results were then compared to those obtained from a group of normal individuals and to the results from a group of other patients with various pulmonary disorders, such as emphysema, pneumothorax, pleural effusion and primary cancer of the lung. None of the patients of all the groups had any appreciable cardiac or circulatory disease.

METHOD OF STUDY

All of the patients had a general physical examination with special attention to the heart and lungs. All had one or more roentgenograms of the chest taken, and an electrocardiogram made. If any further doubt existed concerning the cardiovascular status, the venous pressures and circulation times were determined by the usual accepted methods.

The spirographic studies consisted of the following:

(1) *Resting Spirogram.* After a period of rest in the supine position for one-half hour in a fasting or near fasting state, the patient was connected to a large closed circuit ventilograph metabolism machine. After establishing a "steady state" of breathing the ventilation* and oxygen absorption, were measured for a period of six minutes, followed by three or more determinations of the vital capacity.† Estimation of the maximum breathing capacity was made after the manner of Cournand, Richards and Darling.[1]

From these spirograms one could determine the resting (*a*) ventilation, (*b*) oxygen absorption per minute per square meter of body surface, (*c*) respiratory rate per minute, (*d*) tidal air,‡ (*e*) ventilation equivalent,§ (*f*) the total vital capacity and its subdivisions, and (*g*) the maximum ventilation capacity.

(2) *The exercise spirogram* was made during the recovery period of four to five minutes immediately after the patient had made twelve round trips in two minutes over a stepped platform. This spirogram was made with the subject standing.

From this spirogram the (*a*) ventilation, (*b*) oxygen absorption, (*c*) tidal air, (*d*) respiratory rate, and (*e*) ventilation equivalents were determined for each minute during the recovery period.

The resting and exercise spirograms were made more than once in most of the subjects to check the results.

A tabulation and the average values of each separate resting determination plus the average deviation of error shows the main difference between the normal subjects, the patients with irradiation fibrosis of the lungs and the miscellaneous group (Table 1 and Fig. 1).

The average values for ventilation, oxygen absorption, tidal air and respiratory

* The amount of air passing in and out of the lungs per unit time.

† The greatest amount of air that can be expelled from the lungs on forced expiration after maximum inspiration.

‡ The amount of air passing in and out of the lungs per respiration, during quiet breathing.

§ The number of liters ventilated per 100 cc. of oxygen absorbed in the pulmonary circulation.

TABLE I

AVERAGE VALUES OF RESTING SPIROGRAMS FOR THE THREE GROUPS OF PATIENTS

	M	F	Age	B.S.	V.C.	V.C.m²	C	T	S	V/m²/m	O_2/m²/m	R/m	V.E.	Max. B.C.
Irradiation fibrosis	2	15	51.1 ± 9.5*	1.66 ± .11*	1.79	1.08	1055	400	340	4.12 ± .66	161 ± 24	17.5 ± 3	2.56	36.4
Normal female		9	46	1.71	2.64	1.54	1920	405	310	3.41 ± .27	156 ± 20	14.4 ± 3	2.19	59
Normal male and female	9	9	40.9 ± 11	1.77 ± .13	3.27	1.85	2015	505	705	3.39 ± .45	161 ± 24	12.3 ± 3	2.15	69
Normal male	9		38	1.85	4.10	2.22	2340	600	1150	3.37 ± .63	166 ± 29	10.2 ± 3	2.10	79
Miscellaneous group	17	2	53.7 ± 9.7	1.70 ± .07	2.14	1.26	1270	480	388	4.22 ± .62	165 ± 27	15.6 ± 3	2.56	40.7

* = average deviation; B.S. = body surface in square meters; V.C. = vital capacity in liters; V.C.m² = vital capacity per square meter body surface in liters; C = complementary air in cubic centimeters; T = tidal air in cubic centimeters; S = supplementary air in cubic centimeters; V/m²/m = ventilation per square meter per minute in liters; O_2/m²/m = oxygen absorbed per square meter per minute in cubic centimeters; R/m = respirations per minute; V.E. = ventilation equivalent; Max. B.C. = maximum breathing capacity in liters.

rate are graphed to point out the differences in the response to exercise in the three groups of patients (Fig. 2 and 3).

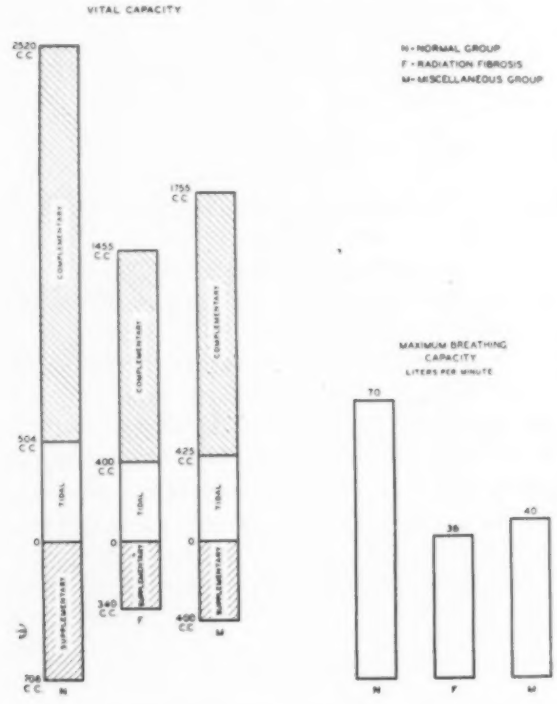


FIG. 1. Chart showing the vital capacities and the maximum breathing capacities of the three groups of patients.

Four patients with moderate to severe degrees of irradiation fibrosis were subjected to bronchospirometry* after the technique of Zavod.[22] These results are given in tabular form (Table II).

DISCUSSION

External respiration depends on (1) the integrity of the pleura and lungs, (2) the function of the thoracic parietes, i.e. skin, subcutaneous tissue, muscles of respiration, skeletal structure, and (3) the mobility of the mediastinum and diaphragm. These structures must function rhythmically by means of an integrated system of nervous reflexes all of which may be markedly conditioned by (1) sensory impulses arising on or within the thorax, or in other parts of the body, (2) chemical changes in the blood, or (3) pressure changes in the blood vessels.

One would expect then, considering the nature of the disease under question, that patients with irradiation pulmonary fibrosis would show abnormal respiratory values in the resting state as well as an abnormal response to exercise.

* A study in which the tidal air, ventilation and oxygen absorption of each lung is measured simultaneously.

The oxygen absorption curves both at rest and during the recovery period after exercise are approximately the same for the three groups of patients (Fig. 2). Minor differences encountered from patient to patient must be attributed to variations in breathing effort, resting metabolic rate and nervous factors. None of the absorption curves in patients with irradiation fibrosis suggested any appreciable degree of anoxemia.[1,9] However, oxygen saturation values for arterial blood have not been determined in these patients.

The chief differences between the normal subjects and patients with pulmonary disease appear to be in (1) ventilation, (2) tidal air, (3) respiratory rate, (4) vital capacity and (5) maximum ventilatory capacity.

The normal ventilation values obtained compare favorably with those reported by other workers.[2,13] In the fibrosis and miscellaneous group the resting ventilation is approximately 12 per cent higher than the normal group. This increase in the absence of anoxemia is probably reflex in origin.

The abnormal ventilation response to excercise in the fibrosis and miscellaneous groups is quite striking and amounts to about 32 per cent over the normal maximum ventilation during the first minute of recovery. This difference decreased gradually but even at the end of five minutes still amounts to 20 per cent, whereas the oxygen absorption at this point is the same as it is in the normal subject. In the absence of anoxemia this suggests that the abnormal ventilation response is reflex in origin and not due to chemical changes in the blood. In a previous study on patients with irradiation fibrosis, the venous CO_2 content and CO_2 combining powers at the end of exercise were all lower than similar resting levels. The pH values were higher at the end of exercise in the same patients.[15]

The curves for the tidal air during the recovery period are quite different for the three groups (Fig. 3). The normal tidal air curve rises to an average of 750 cc. during the first minute of recovery; that of the miscellaneous group rises to 850 cc. but the fibrosis group shows a subnormal response of only 650 cc. Since the minute ventilation for both abnormal groups is approximately the same, the respiratory rate of the fibrosis patients must show a rise greater than the

TABLE II

BRONCHOSPIROMETRY VALUES FOR 4 PATIENTS WITH IRRADIATION FIBROSIS

Patient	V/M		O_2/M		V.E.		V.C. (N)		V.C. (F)	
	N	F	N	F	N	F	C T S		C T S	
1	3.9 (60%)	2.6 (40%)	200 66%	100 33%	1.95	2.6	300 + 260 + 140 (700 cc.)	57%	160 + 170 + 20 (530)	43%
2	4.6 (61%)	2.9 (39%)	200 (80%)	50 (20%)	2.3	5.7	180 + 240 + 0 (420)	60%	100 + 150 + 30 (280)	40%
3	3.1 (50%)	3.1 (50%)	180 (82%)	40 (18%)	1.73	7.65	200 + 180 + 240 (620)	63%	120 + 180 + 60 (360)	37%
4	2.76 (43%)	3.68 (57%)	106 (40%)	160 (60%)	2.6	2.3	100 + 120 + 40 (260)	52%	80 + 160 + 0 (240)	48%

V/M = ventilation per minute in liters; O_2/M = oxygen absorbed per minute in cubic centimeters; V.E. = ventilation equivalent; V.C. = vital capacity; (N) normal lung; (F) fibrosed lung. C = complementary air in cubic centimeters; T = tidal air in cubic centimeters; S = supplementary air in cubic centimeters.

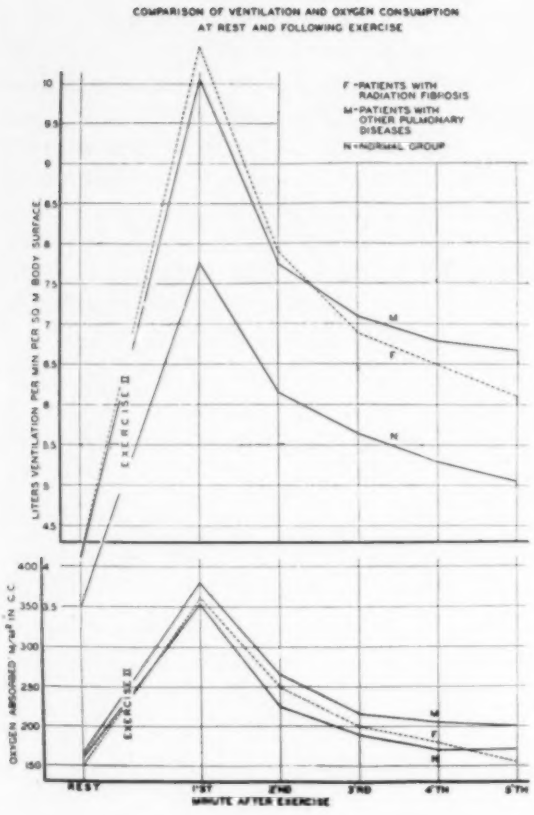


FIG. 2. Chart showing the ventilation and oxygen absorption in the three groups of patients at rest and during the recovery period after the standard exercise.

miscellaneous group. As a matter of fact, the increase of respiratory rate of the fibrosis patients over that of the miscellaneous group is 20 per cent.

The average vital capacity for the fibrosis patients is the lowest of the three groups. The resting tidal and supplementary air values for the normal females and fibrosis patients are about the same, the chief difference being in the complementary phase of the vital capacity. Since the breathing reserve is principally in the complementary phase, the fibrosis patient has less of a margin of safety and comfort as a result of exercise (Fig. 1 and Table 1).

The average maximum breathing capacity of the fibrosis group is the lowest of all three groups. Values of only 25 liters per minute are not uncommon. This value is a measure of the ability of the patient to get air in and out of the lungs and depends on (1) the patency of the tracheobronchial tree, (2) mediastinal and diaphragmatic mobility, (3) respiratory muscular function, and (4) lung capacity. Physical examination, roentgenoscopic and roentgenographic studies already described show that the function of the first three factors as well as the fourth is decreased. This is further attested by the fact that some patients with a radical mastectomy without receiving irradiation also have reduced maximum breathing capacities as well as reduced vital capacities. It is thought that the reduction in those non-irradiated patients is the result of a firm scar of the chest wall and a loss of the pectoral muscles.

The bronchospirograms done on the 4 patients point out several interesting fea-

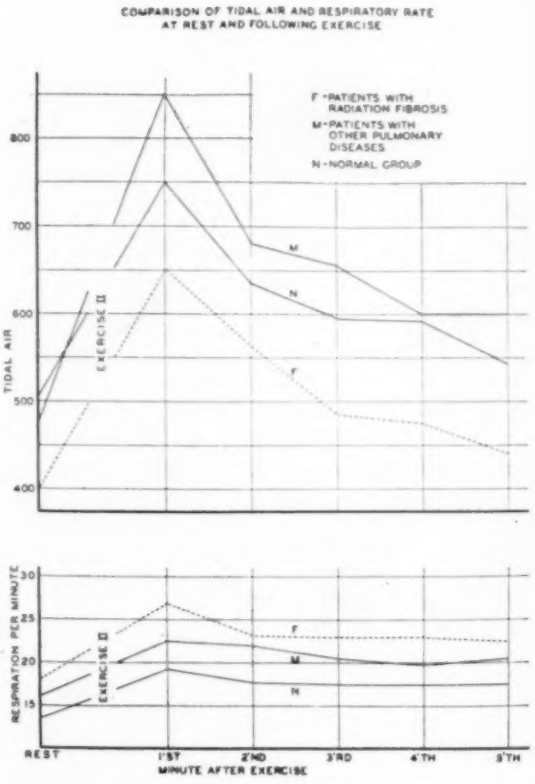


FIG. 3. Chart showing the average tidal air and respirations per minute in the three groups of patients at rest and during the recovery period after the standard exercise.

tures. The oxygen absorption of the diseased lung is quite markedly reduced, whereas the ventilation on the same side is not reduced proportionately when these values are compared to the healthy lung. This disproportionate decrease of oxygen absorption has also been noted by Pinner, Leiner and Zavod[17] in bronchospirograms done on patients with re-expanded pneumothoraces.

Since the irradiation in these patients was given to the upper one-third of the lung field which represents only about one-fourth of the pulmonary volume of that side, such a reduction in oxygen absorption strongly suggests either or both of the following explanations. The remaining lung absorbs oxygen poorly due to secondary alveolar fibrosis beyond the area of irradiation, or the "extrapulmonary factors" seriously interfere with the function of the entire lung.

Some experimental bronchospirograms made with patients who had one side of the chest partially immobilized by sand bags suggest that oxygen absorption in the compressed lung may be lowered disproportionately when compared to the ventilation of the same side. The oxygen absorption of the non-compressed lung increased during the same period.

Further studies on the same subjects with temporary artificial unilateral bronchial stenosis showed both reduced ventilation and oxygen absorption on the affected side, but again oxygen absorption was reduced more than ventilation.

These experiments, however, need further data and clarification but suggest that impaired mobility of the chest wall and bronchial stenosis may be potent factors in the reduction of the oxygen absorption even though the pulmonary parenchyma is not structurally altered.

SUMMARY

From the anatomical and physiological studies carried out, the concept of chronic irradiation pleuropulmonitis must be revised and enlarged. The name pleuropulmonitis connotes only a portion of the entire pathogenesis.

Chronic irradiation pleuropulmonitis is really a disturbance of the entire thorax resulting in (1) fixation of a portion of the thoracic parietal structures, (2) fibrosis of the pleura and lung parenchyma due to irradiation, (3) a secondary alveolar fibrosis beyond the irradiated area, (4) mediastinal fibrosis with partial fixation of the lung hilum, (5) structural changes in the wall and mucosa of the large bronchi, (6) partial immobilization of the diaphragm, and (7) some degree of compensatory emphysema of the untreated side.

The most disabling feature of irradiation fibrosis of the lung is the marked dyspnea that may occur as a result of ordinary excercise. In the absence of heart disease, anoxemia or acidosis, respiratory insufficiency, as pointed out by Cournand and Richards,[2] depends on the relationship between the ventilation per minute and the maximum ventilatory capacity. Both of these values are markedly changed in irradiation pleuropulmonitis. The rise of ventilation per minute is abnormally high and the reduction of the maximum breathing capacity is very great. As a result, mild exercise provokes undue dyspnea. Another factor that cannot be too sharply stressed is that many of these patients were moderately obese. This alone induces greater ventilation reflexly and reduces the maximum ventilation capacity mechanically. The results of these added features are obvious.

Since the disturbance of the parenchymal function is much greater that can be accounted for by the original volume of pulmonary tissue exposed to the irradiation, the conclusion is drawn that the resultant fibrosis far exceeds that produced by the irradiation itself. One wonders if this greater volume of fibrosis is induced by a secondary bacterial infection in the other portion of the lung. This is not as yet clear. However, the results of the experimental data strongly support the premise that the abnormal function of the thoracic wall,

mediastinum and diaphragm is almost as important in causing the pulmonary dysfunction as the pleuropulmonary fibrosis itself. Which of these factors predominates depends on (1) individual susceptibility of the tissues to irradiation, (2) the manner in which the irradiation is given, (3) secondary pulmonary infection, (4) the presence of a scar of the chest wall, and (5) obesity.

REFERENCES

1. COURNAND, A., RICHARDS, D. W., Jr., and DARLING, R. C. Graphic tracings of respiration in study of pulmonary disease. *Am. Rev. Tuberc.*, 1939, *40*, 487–516.
2. COURNAND, A., and RICHARDS, D. W., Jr. Pulmonary insufficiency. I. Discussion of physiological classification and presentation of clinical tests. *Am. Rev. Tuberc.*, 1941, *44*, 26–41.
3. DAVIS, K. S. Intrathoracic changes following x-ray treatment; clinical and experimental study. *Radiology*, 1924, *3*, 301–322.
4. DESJARDINS, A. U. Reaction of pleura and lungs to roentgen rays. AM. J. ROENTGENOL. & RAD. THERAPY, 1926, *16*, 444–448.
5. DOWNS, E. E. Lung changes subsequent to irradiation in cancer of the breast. AM. J. ROENTGENOL. & RAD. THERAPY, 1936, *36*, 61–64.
6. EVANS, W. A., and LEUCUTIA, T. Intrathoracic changes produced by heavy radiation. AM. J. ROENTGENOL. & RAD. THERAPY, 1925, *13*, 203–220.
7. GROOVER, T. A., CHRISTIE, A. C., and MERRITT, E. A. Intrathoracic changes following roentgen treatment of breast carcinoma. AM. J. ROENTGENOL. & RAD. THERAPY, 1923, *10*, 471–476.
8. GROOVER, T. A., CHRISTIE, A. C., and MERRITT, E. A. Roentgen pleuropulmonitis. *South. M. J.*, 1927, *20*, 153–158.
9. HAMBURGER, W. W., KATZ, L. N., COHN, D. J., and RUBINFELD, S. H. Observations on effects of oxygen therapy. I. Clinical observations in heart disease. *J. Am. M. Ass.*, 1932, *98*, 1779–1783.
10. HINES, L. E. Fibrosis of lung following roentgen-ray treatments for tumor. *J. Am. M. Ass.*, 1922, *79*, 720–722.
11. JACOBSEN, V. C. Deleterious effects of deep roentgen irradiation on lung structure and function. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *44*, 235–249.
12. KALTREIDER, N. L., and MCCANN, W. S. Respiratory response during exercise in pulmonary fibrosis and emphysema. *J. Clin Investigation*, 1937, *16*, 23–40.
13. KNIPPING, H. W., and MONCRIEFF, A. Ventilation equivalent for oxygen. *Quart. J. Med.*, 1932, *1*, 17–30.
14. LEACH, J. E. Some of the effects of roentgen irradiation on the cardiovascular system. AM. J. ROENTGENOL. & RAD. THERAPY, November, 1943, *50*, 616–628.
15. LEACH, J. E., FARROW, J. H., FOOTE, F. W., Jr., and WAWRO, N. W. Fibrosis of the lung following roentgen irradiation for cancer of the breast. AM. J. ROENTGENOL. & RAD. THERAPY, 1942, *47*, 740–747.
16. MCINTOSH, HARRIET C., and SPITZ, SOPHIE. Study of radiation pneumonitis. AM. J. ROENTGENOL. & RAD. THERAPY, 1939, *41*, 605–615.
17. PINNER, M., LEINER, G., and ZAVOD, W. A. Bronchospirography. III. Functional capacity of normal lungs, severely damaged lungs, lungs with strictly parenchymal lesions, thoracoplasty lungs, and re-expanded pneumothorax lungs. *J. Thoracic Surg.*, 1942, *11*, 241–265.
18. STRASSER, ALOIS. Pleuritis nach Röntgenbehandlung eines mediastinal Tumors. *Ztschr. f. phys. u. diätet. Therap.*, 1912, *16*, 65–70.
19. TYLER, A. F., and BLACKMAN, J. R. Effect of heavy radiation on pleurae and lungs. *J. Radiol.*, 1922, *3*, 469–475.
20. WARREN, S., and SPENCER, J. Radiation reaction in the lung. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *43*, 682–701.
21. WINTZ, H. Injuries from roentgen rays in deep therapy. AM. J. ROENTGENOL. & RAD. THERAPY, 1923, *10*, 140–147.
22. ZAVOD, W. A. Bronchospirography. I. Description of catheter and technique of intubation. *J. Thoracic Surg.*, 1940, *10*, 27–31.

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THE USE OF THE ROENTGEN RAY IN THE SCIENTIFIC EXAMINATION OF PAINTINGS

By WILLIAM J. ELLIOTT, M.D.
WORCESTER, MASSACHUSETTS

THE roentgen examination of paintings is a recognized method of investigation in practically all art museums throughout the world, but as in the field of medicine, the roentgen examination is only one of the many physical and laboratory tests which may be applied to paintings and other works of art.

Many of the museum laboratories are equipped to do microchemical analysis of bits of paints and the tables and charts[8] used in this work can be compared with the methods of chemical analysis of body fluids in the hospital laboratory. Gettens[7] has prepared paraffin cross sections of fragments of paint taken from a picture in the process of repair and describes many interesting details in the construction of the paint surface.

The phenomenon of substances to absorb certain waves of the electromagnetic spectrum with the emission of waves of different length discovered by John Herschel in 1845, studied by Brewster in 1846 and given the name of fluorescence by Stokes, is used more or less routinely in the examination of paintings and other works of art. Many of the materials used by artists have distinctive fluoresences when examined in ultraviolet light and investigators have used this means to detect damages and repairs in marble, porcelain and other materials. In the examination of paintings in ultraviolet light, areas of repaint may be detected and a few pigments in a comparatively pure state may be identified because of their characteristic fluorescence.

The use of the infra-red rays in medical clinical photography is common knowledge and this form of photography is used in the

FIG. 1. Unknown artist. Portrait of Ann G. Brown. (Courtesy of the Memorial Hospital, Worcester, Mass.)

FIG. 2. Roentgenogram of the portrait of Ann G. Brown.

Fig. 3. El Greco, The Magdalene. (Courtesy of the Worcester Art Museum, Worcester, Mass.)

Fig. 4. Roentgenogram of The Magdalene. Note fine vertical and horizontal brush strokes.

museum laboratory to record restorations which are colored with materials slightly different from the original colors and obscured from the naked eye by dark varnishes (Fig. 9 and 10). Infra-red photographs may also reveal false crackle* which may be painted on or scratched in the ground. False crackle does not have the sharpness produced by the normal action of contraction and expansion. True crackle is readily visible in Figures 13, 14 and 27.

Another form of photography may be used. A strong light may be directed obliquely across the surface of a picture to bring out the surface relief (Fig. 4). These hills and valleys may represent areas of repaint over an old surface and the ridges left by the bristles of the artist's brushes may be recorded more clearly than in a photograph taken by direct lighting.

Examination of the paint surface with the low power microscope may enable the investigator to arrive at the same conclusions about repaint, cracks and surface brushwork.[10] Under the microscope the surface of a painting is usually grossly irregular and traversed by cracks or canyons and any addition to the paint surface in the form of new paint must necessarily remain on the surface. Microscopic examination will usually show the additional colors crossing valleys and touching only the peaks but enough new paint may be present in the crackle to establish the forgery of a signature.

* Crackle: small rifts or fractures developed in the ground or paint film.
Ground: the priming coat applied to the support.
Support: the physical structure which holds or carries the ground or paint film—fabric, wood, metal, stone, plaster, clay, glass, ivory or bone.

ROENTGEN-RAY EXAMINATION

The early roentgen-ray studies of pictures were made in the physicists' laboratories and not in the art museums. Roentgen recorded observations concerning the density of paints in 1896. Töpler in Dresden and König in Frankfort made roentgenograms of paintings and the museum authorities realized that "this application of the Roentgen Rays may prove of considerable value to picture dealers and others in detecting fraudulent imitations of valuable paintings."[6]

In 1913 Faber in Weimar established the scope of the roentgen rays in the study of

Fig. 5. Flemish, unknown. Guillemette de Toulongeon and her Patron Saint. Partial restoration. (Courtesy of the Worcester Art Museum, Worcester, Mass.)

Fig. 6. Cross light, partial restoration.

Fig. 7. Painting on reverse side of panel, very early Flemish.

Fig. 8. Portrait of Guillemette de Toulongeon and her Patron Saint. After restoration.

Fig. 9. French, artist unknown. Before restoration. Damage faintly visible. (Courtesy of the Worcester Art Museum, Worcester, Mass.)

Fig. 10. Infra-red, extent of damage accentuated.

paintings, but Wehlte[12] states that no systematic study was undertaken in Germany until 1928, after the William Hayes Fogg Art Museum, Harvard University, had sent two expeditions to Europe to collect roentgenograms of famous paintings. At the present time the Fogg Museum roentgen-ray file contains approximately 3,200 roentgenograms representing the work of "more than three hundred Italian artists, about one hundred Dutch, seventy Flemish, fifty French, fifty American, thirty German, twenty-six English, and fifteen Spanish painters."[1]

Roentgenograms of paintings represent records of the differences in density and thickness of materials used in making a picture. Satisfactory roentgenograms are obtained at the Worcester Art Museum with the following technique: 35 kv. (peak), 6–8 ma., 1 mm. focal spot, 6 ft. distance, exposure time of 12 to 20 seconds, depending on the thickness of the support (canvas or panel). "No-screen" films are used routinely and the dark room technique is similar to that in the medical laboratory. Roentgenoscopy is not used in the Worcester Museum but the Museum of Fine Arts, Boston, has an elaborate roentgenoscopic unit.

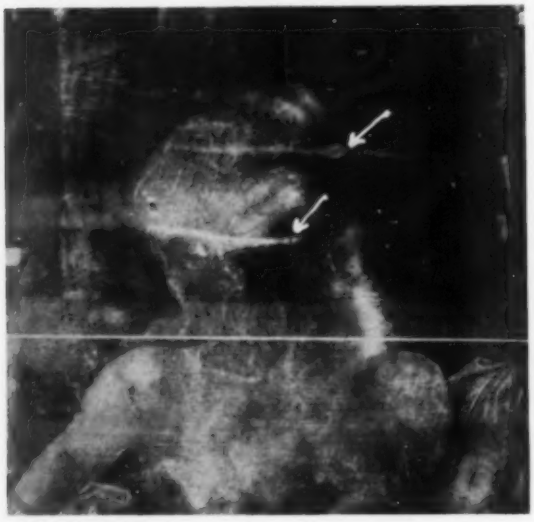

Fig. 11. Roentgenogram showing crack in panel filled with white lead; composite print from two 14 by 17 in. films.

Fig. 12. After restoration. Note change in lower left corner.

Fig. 13. Edward Savage, Portrait of his Son. (Courtesy of the Worcester Art Museum, Worcester, Mass.)

Fig. 14. Roentgenogram; revisions indicated by arrows.

Stereoscopic soft roentgen-ray (3–18 kv., peak) examination of parchment antiphonaries has been reported by Sherwood.[11] He states that the negatives, when viewed in a special magnifying stereoscope, reveal successive layers of paint and variation in type of pigment used in the paints. This method of examination is not applicable to old paintings because of the heavy priming coat applied to the ground, but conventional stereoscopic views are of value in differentiating the layers of paint on the front and back of a panel when paintings are present on both sides (Fig. 5 and 7).

White pigment prepared from lead has been used from the early Renaissance down through modern times. It has been used to repair defects in wood panels (Fig. 11), to form the base or priming coat, to raise the tone of a pure color, to reproduce high lights and all white or luminous objects in the paint film. Because of the density of the priming coat, some of the vegetable colors and chemical compounds, the blacks and dark tones, as well as the thin glazes used for shadows by many artists, are not visible on the roentgenogram, and as Burroughs points out, "the net result is that one studies with X-rays the use of white in painting."[1] This statement is strikingly illustrated in the photograph and roentgenogram (Fig. 1 and 2) of a portrait in the Memorial Hospital, Worcester, Massachusetts. The roentgenogram reveals the dense pigments which create the three dimensional design in much the same manner as they are created by the use of a black crayon on white paper. The peculiar cracks which outline the hair and neckerchief may be caused by glazing the delicate shadows with a quick drying medium.[3] The fine vertical and parallel lines seen in the roentgenogram are not "Bucky stripes" but represent the dense pigment of the priming coat or ground in the warp and weft of the support.

The roentgenogram of the head of the Magdalene (Fig. 4) by El Greco also illustrates the use of white pigment and when compared with Figure 2, an altogether different type of brush work is noted. Short linear strokes were used by El Greco to

Fig. 15. Palma Vecchio (?) Portrait of Man, before cleaning. (Courtesy of the Worcester Art Museum, Worcester, Mass.)

produce the "composition expressing human sorrow and exaltation with a degree of power rarely approached by any

Fig. 16. After initial cleaning.

painter."[4] To the medical diagnostician, the fullness of the neck and the "widening of the slits and brightness of the eyeball, hardly ever occur in pure adenomatous goiter or colloid goiter,"[9] so the tentative diagnosis of exophthalmic goiter is suggested.

Casual observation of the first print (Fig. 15) in the series of the Portrait of a Man, attributed to Palma Vecchio, may also suggest a medical diagnosis—torticol-

Fig. 17. Roentgenogram showing the hidden eye.

lis. This diagnosis is more apparent in Figure 16 as the relationship of the head and body is certainly not a natural pose. This fact was readily recognized by the Museum authorities and not satisfied with the appearance of the painting after the first cleaning, roentgenographic study revealed the faint outline of an eye which did not correspond to either of the eyes seen on the paint surface. The mass of white pigment about the hidden eye was sufficient proof that the "torticollis" had occurred after the head had been painted in a

Fig. 18. Second restoration, incomplete.

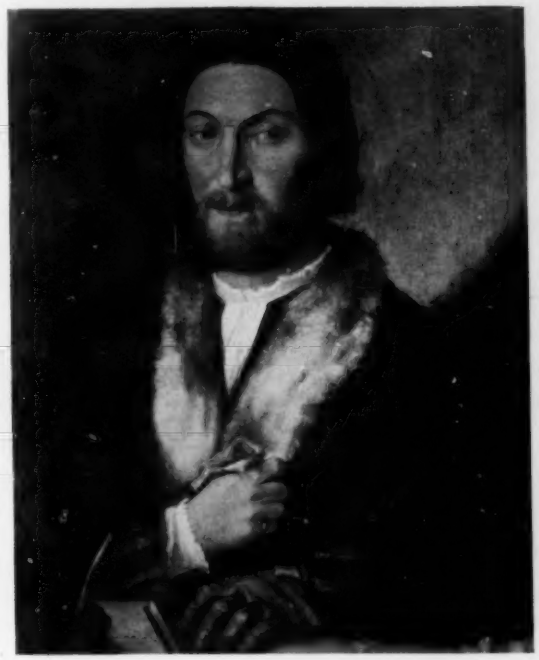

Fig. 19. After restoration.

Fig. 20. Attributed to Lorenzo Lotto, Portrait of a Woman. (Courtesy of the Worcester Art Museum, Worcester, Mass.)

Fig. 21. Roentgenogram showing morning, afternoon and evening dresses.

FIG. 22. Unsigned portrait, Mrs. Offin Boardman and Child. (Courtesy of the Worcester Art Museum, Worcester, Mass.)

FIG. 23. Unsigned portrait, Mrs. Offin Boardman. Compare with Figure 22.

natural position. A photograph made during the second restoration process (Fig. 18) shows the "hidden eye" seen on the roentgenogram. Certainly the sitter is not tormented by contraction of the cervical muscles as shown in Figure 19, but as art history does not reveal his identity, there is no proof that this individual did not develop a wryneck after the initial painting.

Diagnositic errors in the medical field, comparable to misattribution in museum work, are made less frequently when the patient, human or work of art, is subjected to certain modern laboratory procedures. Lorenzo Lotto (Venetian, ca. 1480–1556) has been cited for many years[4] as the painter of the forbidding character in Figure 20. The roentgenogram of this painting (Fig. 21) was among the first made by me at the Worcester Art Museum and, needless to say, my interest in this line of investigation was greatly stimulated by the discovery of the round neck and "V" neck gowns hidden by the square neck dress of the surface paint. Such a wide variation in design on a single small panel (13 by 11 inches) is usually considered of student or "School" origin. (The cross bars of wood visible in Figures 21, 25 and 27 represent the "cradle" applied to the backs of paintings on wood to minimize warping.)

It is a well known fact that the technical work as shown by the quality of the roentgenograms may vary from laboratory to laboratory, and even within the same laboratory, because of the human element necessary in the selection of the voltage, the placing of the patient and attention to other details too numerous to mention. Roentgenograms of paintings by different artists readily reveal differences in actual workmanship between pictures which outwardly may be quite similar. Burroughs[2] has shown a series of such comparisons, the least subtle is that between two pictures in the Brussels Museum, identical in composition. Figure 25 is the roentgenogram of a small section of the painting Numbering at Bethlehem, copied by Pieter Brueghel, the Younger, from the work of his father, Old Brueghel. The roentgenogram of Old Brueg-

hel's painting (Fig. 24) shows careful workmanship in contrast to the thin linear design in the copy. In Old Brueghel's painting the snow, seen in the roentgenogram because of the density of the white lead, is distributed thickly over the most exposed parts of the cart, and less thickly over the parts less exposed. In the copy the snow appears to be spread evenly over the tops of large surfaces, lies vertically on the upright spokes and yet does not cover the hub

Fig. 24. Old Brueghel, Numbering at Bethlehem. Roentgenogram of cart. (Royal Museum, Brussels.)

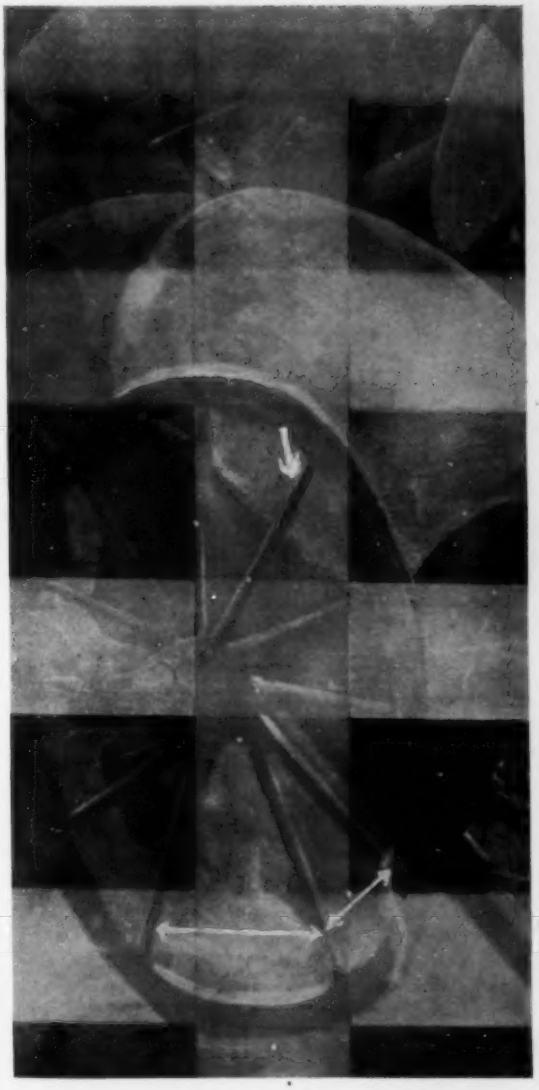

Fig. 25. Roentgenogram of copy, by Pieter Brueghel, the Younger. (Mr. Alan Burroughs kindly loaned the copies of the roentgenograms of the Brueghels' painting.)

of the wheel. Old Brueghel used a variety of small strokes and established relationships with care while the brush marks in the copy appear unusually heavy and do not transcribe relationships.

Another comparison of identical compositions can be found in two portraits in the American Antiquarian Society, Worcester, Massachusetts. The roentgenogram of Pelham's Cotton Mather (Fig. 26) reveals a variety of brush strokes in contrast to the

Fig. 26. Cotton Mather by Pelham. Roentgenogram of the original. (Courtesy of the American Antiquarian Society, Worcester, Mass.)

Fig. 27. Roentgenogram of copy of Pelham's portrait, artist unknown.

flat surface of the copy (Fig. 27). The damaged areas and crackle in the paint surface of the copy are readily visible.

Full scale prints of areas including the brow, eye and nose from roentgenograms of two unsigned portraits in the Worcester Art Museum reveal identical brush work, therefore these portraits were painted by the same artist (Fig. 22 and 23). In this particular instance the identity of the artist (Christian Gullager, American 1762–1826) was quickly established by comparison with roentgenograms of signed portraits by this American painter. In most instances the character of the brush strokes is as constant as the variation in the anatomical structure of the first rib or the size, position and number of phleboliths in the pelvis, which will definitely establish for the roentgenologist the identity of a patient from a roentgenogram of chest or abdomen when roentgenograms made at previous examinations are present for comparison.

An artist may change his technique or style during the course of his career as shown in the life-size study of An Old Woman at Prayer, Nicholas Maes (Fig. 28 and 29). Maes painted the old woman on a canvas already used for the portrait of a young lady and in the roentgenogram the thin pigments used to model the old woman are obscured by the heavy impasto of the portrait which will never be seen. Only the folds of the neckerchief and faint outline of neck and face of the old woman are visible in the roentgenogram. Art history tells us that Maes shifted from a heavy impasto to fluid glazes and this change in style is quite evident in the roentgenogram.

Forgers and forgeries may be found in every line of human endeavor and the critics and connoisseurs in the museums must decide between the real and false. Fakers of

Fig. 28. Nicholas Maes, Woman at Prayer. (Courtesy of the Worcester Art Museum, Worcester, Mass.)

Fig. 29. Roentgenogram of Figure 28 showing hidden picture, folds in the neckerchief of the Woman indicated by arrow, neck and face of Woman faintly visible.

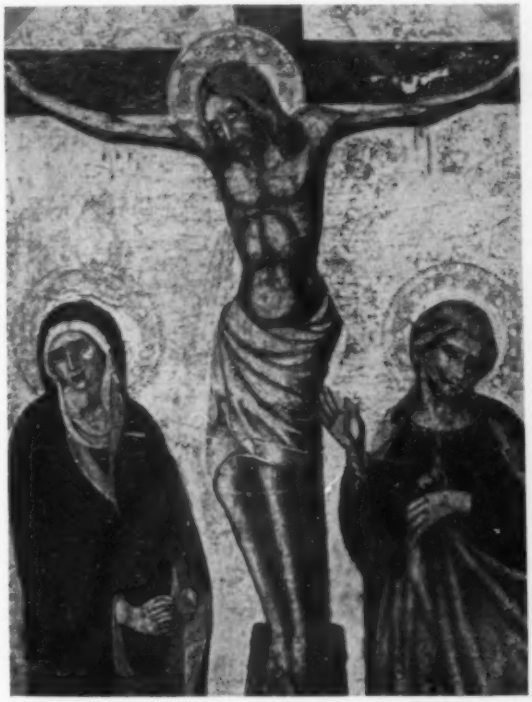

Fig. 30. Forgery after style of Luca di Tommé. (Courtesy of the Metropolitan Museum of Art, New York.)

Fig. 31. Roentgenogram of forgery showing filled worm holes.

"Old Masters" have existed for hundreds of years and to distinguish between the genuine and counterfeit rests on the laboratory and aesthetic critic. Chemical analysis of paint may reveal zinc white from a "XIVth Century Piece" but according to the Chronological Chart of Pigments published by de Wild,[5] zinc white was first used during the latter part of the 18th Century, thus the chemical examination alone may brand the piece as a forgery. The study of the crackle has been mentioned in the paragraph dealing with the use of infra-red photography. The differentiation of true and false crackle, together with variations in the placing of pigment and wide variation in brush work as seen in roentgenograms may be the deciding evidence between the genuine and counterfeit. A most obvious example of forgery is the painting after the style of Luca di Tommé (Fig. 30 and 31) in the Metropolitan Museum of Art. The wooden panel is old and the ground applied directly to the surface, fills worm holes and a split in the knotty wood. A simple comparison between the front and back surfaces shows that the worm holes have been filled on the front of the panel and as no artist would paint a picture on a wormy piece of wood, paint added after worm holes have appeared is a certain sign of forgery.

Shall it not be scorn to me to harp on such a
moulder'd string?
I am shamed thro' all my nature to have
loved so slight a thing.

Alfred, Lord Tennyson

REFERENCES

1. BURROUGHS, ALAN. Art Criticism from a Laboratory. Little Brown & Co., Boston, 1938.
2. BURROUGHS, ALAN. Art Studies, VIII, Pt. 2, 61.
3. BURROUGHS, ALAN. Personal communication.
4. Catalogue of Paintings and Drawings, Worcester Art Museum, 1922.
5. DE WILD, A. MARTIN. The Scientific Examination of Paintings. G. Bell & Sons, London, 1929.
6. Editorial. *Electrical Rev.*, London, April 30, 1897.
7. GETTENS, R. J., A microsector for paint film. *Technical Studies*, 1932–1933, *1*, 20.
8. GETTENS, R. J., and STOUT, G. L. The stage microscope in the routine examination of paintings. *Technical Studies*, 1935–1936, *4*, 207.
9. GOETSCH, EMIL. Diseases of Thyroid. The Cyclopedia of Medicine, Vol. XII, page 129. F. A. Davis Co., Philadelphia, 1934.
10. LOURIE, A. P. Technical notes. *Museum Journal*, 1932, *32*, 166.
11. SHERWOOD, H. F. Stereoscopic soft x-ray examination of parchment antiphonaries. *Technical Studies*, 1937–1938, *6*, 277.
12. WEHLTE, KURT. X-ray Examination of Paintings in the Stadel Art Institute. *Stadel Jahrbuch*, 1932, *7–8*, 220–227.

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THE TREATMENT OF ASTHMA WITH THE ROENTGEN RAY*

By IRA I. KAPLAN, B.Sc., M.D., *and* SIDNEY RUBENFELD, B.Sc., M.D.†
Radiation Therapy Department, Bellevue Hospital
NEW YORK, NEW YORK

IN 1906 Schilling examined roentgenographically the thorax of a patient suffering with asthmatic paroxysms to determine the presence of a foreign body and the following night the patient slept without a seizure for the first time in three years. Not long after that observation had been made, roentgen therapy came to be employed frequently in treating bronchial asthma, and numerous reports have appeared in the literature. The present survey was undertaken to record the results obtained in the Radiation Therapy Department at Bellevue Hospital.

THEORIES

There has been, to date, no definition of the modus operandi of irradiation to explain satisfactorily its influence upon asthmatic paroxysms. The very fact that numerous types of radiation treatment have been employed, and all with like results, adds to its inexplicable nature.

Naturally, treatment directed to the chest was believed to exercise the influencing effect, and this procedure was used for many years. When refractory cases were encountered, the procedure shifted to irradiation of the spleen and soon there followed a technique which included irradiation of both chest and spleen. Others suggested treatment of the pancreas and liver. Later, it was believed that some disturbed thyroid function might be influenced by irradiation, and this, in turn, help the paroxysms. Similarly, dysfunction associated with secretion of the adrenals led to roentgen therapy to that organ. Again, an ill-defined relationship between the hypophysis and asthma led to treatments administered to this gland. Possibly because of some fault in the influence of the cervical sympathetics, roentgen therapy to this nerve system was also given a trial. Finally, the entire trunk was irradiated and with some successful results. Irradiation of the endocrine system, however, had little success.

Accordingly, there are many theories as to the rôle played by irradiation in the treatment of asthma. Theories of the mechanism of action of roentgen therapy in the asthmatic syndrome fall into five groups: (1) those which take into consideration more or less exclusively the local factors, hilar adenopathy, peribronchial infiltration, mucosal hypersecretion, thymic hypertrophy, etc.; (2) those which admit an action on the endocrine system; (3) those which relate the entire mechanism to a direct or indirect action on the autonomic nervous system; (4) biochemical theories which allege an action on the biochemicophysical state of the plasma, and (5) allergic theories which assign to irradiation a rôle equal to that of protein therapy, namely a desensitizing action by means of slight repeated shocks caused by the appearance in the circulation of products of cellular radiolysis.

That the favorable action is due to the relief of the pressure effect of tracheobronchial lymph nodes is advocated by some authors. Others believe that the action is on the sympathetic nerve chain whether the rays are directed to the lung or hilar region (Altschul[1]). A probably destructive effect on the lymphatic channels of the lung was offered by Ramirez and Cole[8] and diminished irritability of the vagus fibers was suggested by Gerber[5] and Zuppa[11] as the explanation of the irradiation effect. Cola[3] expressed the opinion that the mucosa is relieved of congestion. Others, as Pöhlmann,[7] believed that only by irradiation of the spleen will results be obtained

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† On active duty with the United States Army.

wherein there is an influence on the anaphylactic disposition of the individual, or as Gerber thought, splenic irradiation releases antibodies which modify the anaphylactic seizures. Torelli[10] held that there may be a nonspecific desensitizing action similar to protein therapy produced by slight repeated shocks caused by substances resulting from cell decomposition. Grävinghoff,[6] in 1931, stated that the allergic processes of the vegetative nervous system are altered to affect the acid base balance. Anzilotti[2] suggested that the result was due to protein shock following sufficient irradiation to cause a general reaction. Cola believed that the equilibrium of the colloids is re-established. Zuppa held that irradiation of the adrenal increases secretion of adrenalin which acts on the sympathetic system and balances the vagosympathetic equilibrium. Ramirez and Cole advanced the idea that the effect is on the hydrogen ion concentration of the bronchial cells or a change in the colloids of the cells. Scott[9] believed that secondary changes are produced to affect the entire body, and in his method of treatment the trunk is exposed to the rays.

In reviewing the foregoing theories advanced to explain the effect of irradiation, they may be summarized as follows (from Desjardins[4]):

(1) Action on tracheobronchial lymph nodes.
(2) Circulation of hormones.
(3) Elevation of the stimulation threshold of the antigens.
(4) Stimulation of antibodies.
(5) Desensitization of the body to proteins.
(6) Diminished hyperesthesia.
(7) Complex indirect influence on the whole body.

To these numerous possible explanatory reactions, we have none to add nor would we even attempt to favor one over the other. Although possessing no experimental proof, we are of the impression that these patients have become allergic to a bacterial infection inherent in the bronchi, and that with irradiation we are combatting the infectious process.

Anzilotti states that radiotherapy should be limited to true essential bronchial asthma, meaning thereby the paroxysmal respiratory syndrome of a spasmodic vasomotor and vasosecretory character. He advises against treatment where asthmatic and organic pulmonary lesions exist simultaneously.

Numerous authors employing varying techniques have reported favorable results and cite their evidence of improvement in the majority of patients. Obviously, in the absence of standards as to what constitutes improvement, the personal equation enters into the statements of these writers. In general, it would seem that more than half the patients have been benefited; only the report of Ramirez and Cole indicates a greater percentage of failures than successes.

TABLE I

AGE AND SEX

	0–10	11–20	21–30	31–40	41–50	51–60	61–70
	1	3	9	16	27	6	4=66
Male	1	2	2	9	24	4	3=45
Female	0	1	7	7	3	2	1=21

PRESENT SERIES

We were afforded the opportunity of treating a group of 95 cases of whom, however, only 66 were included for analysis because there were observed for a sufficient time after treatment. Patients who received a series of roentgen therapy and never returned—a not uncommon experience at Bellevue Hospital—were not found suitable for analysis.

As Table 1 clearly indicates, we have seen most patients for treatment between

TABLE II

DURATION OF ILLNESS

Years to	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	24	25	40
No. of Cases	6	7	11	1	5	5	1	2	3	2	1	0	2	0	2	3	0	2	1	6	2	1	1

TABLE III

FREQUENCY OF PAROXYSMS

No. Attacks per Day	1	2	3	4	5	6	7	8	9	10	Every 3 days	Once weekly	Irregular intervals
Cases	13	3	5	1	4	3	1	5		3	3	2	31

the third and fourth decades in which males show a definite preponderance. These figures, however, do not indicate the duration of the disease because, as Table II illustrates, there is a wide distribution over years of duration of the illness.

Without a firm definition of asthmatic paroxysm, it is difficult to distinguish the degrees of severity of the disease, or the amount of improvement obtained. Many patients will suffer from constant shortness of breath objectively recognized by labored breathing, and occasionally will suffer an acute attack characterized by the familiar, vicious paroxysm during which breathing becomes extremely difficult and attempts to summon aid of all respiratory muscles are made; cyanosis, sweating and tachycardia intervene, and suffocation appears impending. These attacks must be differentiated from the milder symptom of constant shortness of breath. In Table III, the statement of the frequency of paroxysms refers to the severe suffocating attacks which necessitate adrenalin injections. Their severity and seriousness are indicated by their frequent occurrence; as an instance, 3 patients had as many as ten such attacks per day.

For relief, 28 of 46 patients were accustomed to taking adrenalin, and the figures in Table III refer to the number of attacks which occurred in such severity that adrenalin had to be used.

ALLERGIC MANIFESTATIONS

The patients reviewed in this series were all carefully studied on the medical services. Distinct sensitivities were determined and corrective measures introduced, such as desensitizing agents. Eventually, the patients were referred to the radiation therapy clinic because of failure with other methods. Numerous patients exhibited no specific measures; others showed specific allergies as follows (Table IV):

TABLE IV

SENSITIVITY TESTS

Material	No. of Cases	Material	No. of Cases
Fur	3	Coffee and cheese	1
Dust	8	Powder	2
Timothy and ragweed	5	Many things	3
Oranges	1	Paper	1
Cat dander	1	Cold weather	1
Feathers	3	Aspirin	1
		Silk	1

Without specific reactions, but of possible etiological significance, the following conditions are listed as appearing prior to the onset of the first asthmatic attack (Table V). Some had combined conditions, for example, sinusitis and pneumonia, tonsillitis and bronchitis.

TABLE V

Condition	No. of Cases	Condition	No. of Cases
Pneumonia	6	Pregnancy	1
War gas	1	Sinusitis	2
Several resections of nasal polyps	6	Hayfever	1
		Erysipelas	1
Severe cold	7	Eczema	1
Empyema	1	Tonsillitis	1

TECHNIQUE OF THERAPY

All patients were treated with the same technique as regards the factors of irradiation; namely, 200 kv., 5–20 ma., 0.5 mm. Cu plus 1 mm. Al filter, 40–50 cm. distance. With unit doses of 100–150 r (measured in air) treatments were given twice or three times weekly, until a dose of 600 r was given. In this, the usual procedure was to irradiate the thorax with an open field at 40 or 50 cm. distance, alternating anteriorly and posteriorly until each side received 600 r.

Some modifications in this routine were instituted to control the spasms. Thus, 6 patients received 1,200 r rather than 600 r. Several had from 700 to 1,000 r and 1 case had 1,800 r. These were irradiated over the splenic area alone, 1 case received treatment over the sinus area in addition to chest treatment and 3 cases had splenic treatment in addition to chest treatment. Lastly, 4 patients were treated over the cervical area in an effort to irradiate the cervical sympathetic chain.

RESULTS

Fifty-six patients received irradiation over the thorax. Of these, 36 were relieved of their anxious spasms at the end of one series of 600 r. Eight patients needed 700–1,800 r before they exhibited relief. In 5 other cases, relief was only mild as indicated by persistent shortness of breath bordering on a paroxysm. No change at all was reported in 9 cases. The 13 cases who were irradiated over the cervical sympathetic chain exhibited little or no response. Interestingly enough, splenic treatment in 4 cases produced complete relief from the paroxysms.

Recurrence of attacks are, unfortunately, the rule rather than the exception. The time between initial relief and recurrence of attacks is indicated in Table VI.

TABLE VI

Month	1	2	3	4	5	6	8	10	14	19	24	
No. of Cases	4	7	3	3	1	3	1	1	1	1	1	1=26

The second series of treatments was instituted and the following results disclosed: The thorax was irradiated in 16 cases with relief; 4 showed a negative response. Treatment to the cervical sympathetic chain aided 1 case and failed in 2 other cases.

A broader analysis of the results obtained can be tabulated as follows:

I. Controlled: Those patients in whom one or more series of roentgen therapy were successful in relieving the paroxysms.

II. Moderately controlled: Those patients in whom the first series of roentgen therapy was successful, but subsequent attacks were not successfully arrested.

III. Non-controlled: Irradiation had no influence in stopping attacks.

Using these arbitrary classifications, the results in our series showed the following:

Group I—48 cases, or 72.7 per cent
Group II—5 cases, or 7.5 per cent
Group III—13 cases, or 19.7 per cent

DISCUSSION

Based upon observation of these cases, we have formed certain impressions as to the reaction to irradiation. In general, it appears that the more severe the disease as characterized by numerous and intense paroxysms, the better the response to irradiation. As a corollary, the longer the duration of the disease, the more efficient was the treatment. In the majority of cases, the recurrent attacks after irradiation had been instituted were definitely less severe in nature.

In responsive cases, the sequence of events is usually an increased production of sputum, and an aggravation of the severity and number of attacks. These changes may ensue within hours after treatment has been administered. Soon there is some amelioration so that the anxious patient is eager for the next dose. After the fourth or fifth treatment the satisfactory change may be more lasting. When freedom from

attacks resulted the general condition improved, often rapidly, as evidenced frequently by a rapid gain in weight. There are numerous cases in this series that have been controlled over a period of many years, for as soon as signs of shortness of breath appear, treatments are re-instituted and the patient may continue for years without attacks. It appears, therefore, that notwithstanding the absence of a sound rationale for radiation therapy, and with varying techniques, roentgen therapy is definitely successful in controlling the paroxysms of asthma. When it is borne in mind that there was no alternative treatment for these persons, who were either sensitive to all proteins, or to none at all; who had no medicinal resources to call upon, and who even after twenty years of suffering from the disease, gain either considerable or absolute relief after being given roentgen therapy, then the method must be hailed as a valuable addition to our armamentarium of treatment. And even those cases which were only moderately relieved were given an opportunity to carry on when previously they were invalids.

The following case is illustrative of such satisfactory response. Previously, this patient had received frequent injections of adrenalin with only transitory relief. Following the seventh dose of roentgen radiation, all paroxysms disappeared. He was free of attacks for one year, when there was a recurrence. This, however, responded in a similarly satisfactory manner to roentgen treatment. He received occasional treatments for several years, the last being administered in June, 1941. He was last seen and examined at the clinic on March 5, 1942, had no complaints, was free of attacks, but had a feeling of tightness in the chest.

CASE REPORT

R. H. (8486), male, aged forty-five, married, admitted September 14, 1933, complaining of severe asthmatic attacks. He had suffered from sinus trouble for many years and had two nasal operations with bone removal. He had also had a recent tonsillectomy. For the past three years he had had frequent attacks of asthma which required repeated injections of adrenalin. Physical examination revealed no abnormality except emphysema of the chest with sonorous and sibilant râles. Roentgen examination showed only some increased hilar markings. The diagnosis was bronchial asthma. While on the medical ward for five weeks he had been receiving five injections of adrenalin each day.

Roentgen treatment was administered to the anterior and posterior chest and after seven treatments, given within an eight week period, he was definitely relieved and completely free of attack and required no further adrenalin injections. It was noted that marked relief occurred even after the fourth roentgen treatment. Occasional attacks occurred and were relieved by roentgen therapy. The last treatment was given in June, 1941, and when seen in March, 1942, the patient had been free of asthma for one year.

SUMMARY

(1) Numerous theories are held as to the modus operandi of irradiation in asthma.

(2) Many techniques and irradiation over various areas of the body have been employed by many authors.

(3) In our series, all ages were affected by the disease but more commonly males between thirty and fifty years.

(4) Various patients were allergic to many proteins or none at all, and were not helped by desensitization therapy.

(5) The technique of irradiation is outlined.

(6) In the entire series, 72.7 per cent of the patients found relief from the asthmatic paroxysms after irradiation.

(7) It is noted that the longer and more severe the illness, the more favorable the response to irradiation.

(8) In the roentgen treatment of asthma aggravation of symptoms often preceded amelioration.

755 Park Avenue
New York, N. Y.

REFERENCES

1. Altschul, W. Bei welchen Bestrahlungen spiel. der Sympathikus eine Rolle? *Strahlentherapie*, 1934, *50*, 669–676.

2. ANZILOTTI, A. La roentgenterapia delle sindromi asmatiche. *Quaderni di radiol.*, 1938, *3*, 157.
3. COLA, G. La fisioterapia adell'asma bronchiale. *Arch. di radiol.*, 1933, *9*, 709–733.
4. DESJARDINS, A. U. Action of roentgen rays and radium on the lungs. AM. J. ROENTGENOL. & RAD. THERAPY, 1932, *28*, 127–144.
5. GERBER, I. Roentgen-ray treatment in bronchial asthma and chronic bronchitis. *J. Am. M. Ass.*, 1925, *85*, 1026–1029.
6. GRÄVINGHOFF, W. Zur Röntgenbehandlung des kindlichen Asthmas. *Strahlentherapie*, 1931, *42*, 492–496.
7. PÖHLMANN, C. Irradiation of the spleen in bronchial asthma. *München. med. Wchnschr.*, 1925, *72*, 57–58.
8. RAMIREZ, M. A., and COLE, L. G. Roentgen-ray therapy in bronchial asthma. AM. J. ROENTGENOL. & RAD. THERAPY, 1925, *14*, 322–372.
9. SCOTT, S. G. Method of treating asthma by radiation. *Brit. M. J.*, 1926, *1*, 939–941.
10. TORELLI, G. La roentgenterapia dell'asma bronchiale. *Radiol. med.*, 1930, *17*, 16–37.
11. ZUPPA, A. Roentgenterapia della glandole surrenali per la cura dell'asma bronchiale essenziale. *Arch. di radiol.*, 1933, *9*, 1117–1118.

DISCUSSION

DR. MERLE M. MILLER, Philadelphia. After hearing Dr. Kaplan's discussion and after spending the last two nights with three patients who have asthma, I think he has sold me something.

There are several things that we have to consider before we give a patient roentgen therapy, and the first is that we should pick our cases and take only intrinsic asthmatics, those patients who do not have an extrinsic sensitivity or those who do not have a sensitivity to inhalants and food proteins. Second, before we give roentgen treatment, all of these patients certainly should have complete medical and allergic examinations, and they should not be given roentgen treatment until they have had a complete regimen of therapy from the standpoint of allergy and internal medicine.

Another thing I think we have to consider in treating these patients is that any prescription or any proprietary preparation or any procedure will often relieve them for a short period of time, and I believe sometimes, too, the psychic element enters into almost any treatment of an asthmatic, and if I were a patient and saw all the imposing deep roentgen therapy equipment I feel that I would recover from my attack too.

We have observed between 60 and 70 patients who have been treated by roentgen therapy. Some of them have had good results, but I agree with Dr. Kaplan and with Drs. Maytum and Leddy of the Mayo Clinic, who state that the longer the duration of the asthma, the more favorable is the response to radiation therapy. If I may, I should like to compare the results of Maytum and Leddy with Dr. Kaplan's series of cases. I have been following Maytum and Leddy's work since 1935. They have treated 215 patients of which 161 are included in their series. Thirty-eight, or 24 per cent, obtained marked relief designated as 75 per cent results; 26, or 16 per cent, were moderately relieved; 23, or 14 per cent, had marked relief but were receiving other therapy at the time; 74, or 46 per cent, obtained less than 50 per cent and are classified as failures; 5 patients thought they were markedly worse following treatment.

Drs. Kaplan and Rubenfeld have treated 95 patients and 66 are included in their survey. The paroxysms were relieved in 48, or 72.7 per cent of the cases; 5 patients thought their asthma was markedly worse following radiation therapy and that often happens. They do feel worse after they have been exposed to the roentgen ray; therefore, often it is well to give a dose of adrenalin before and after. Nineteen per cent of Dr. Kaplan's cases did not receive any effect.

I think that roentgen therapy can probably be used as an adjunct in the treatment of intrinsic, so-called bacterial asthma. I am going to ask Dr. Kaplan if in treating a patient it has any effect whatever on the acute paroxysms which the patient has.

The only difference I can see in these two groups of cases is that they start treatment too soon at the Mayo Clinic.

DR. KAPLAN (closing). In answer to Dr. Miller, we do not treat the patient in the acute stages. One of the reasons is that the patient never comes to us directly. He is transferred only after he has been on the medical service.

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SPONTANEOUS RIB FRACTURES FOLLOWING IRRADIATION FOR CANCER OF THE BREAST

By ASA B. FRIEDMANN, M.D.
Visiting Radiation Therapist, Kings County Hospital
BROOKLYN, NEW YORK

THE purpose of this paper is to record a case of multiple spontaneous rib fractures occurring as a delayed irradiation injury in the treatment of cancer of the breast.

Late irradiation injuries to the skin and cartilage have long been known. With the advent of divided dosage technique and the concomitant marked rise in total dosage to both tumor and intervening normal structures, dormant structural injuries to the intestines, lungs and bone have been reported. Spontaneous osteoradionecrosis of the jaw following treatment for intraoral cancer is one example. Spontaneous hip fracture following the use of lateral fields in irradiation for cancer of the cervix is another. These injuries constitute in themselves a criticism of radiation as a therapeutic agent but do not argue against the use of radiation in increasingly large dosage in the treatment of cancer.

The effectiveness of radiation is a factor of the quantity of energy absorbed in the tissue and that quantity must be sufficient to be lethal to the tumor, or else the treatment is futile. The differences in the susceptibility to radiation of normal and tumor tissue permits the use of radiation therapy altogether. The rate of administration both per dose and the spreading of the total dose through an increasing number of days (protraction and fractionation) permits the differences in the recovery rates of normal and tumor tissue to come into play. One factor not sufficiently emphasized is that this so-called difference in recovery rate may represent in some degree rather differences in the latent periods required until the destructive changes become evident. As more and more cancer patients are successfully irradiated through the use of larger total doses over longer periods and lives are prolonged, we can expect to see increasing numbers of late irradiation injuries to the normal structures in the path of the roentgen-ray beam.

With the advent of the method of Coutard and its various modifications the total dose that can be administered has greatly increased and the local control of certain cancers has shown an associated rise. Notably in this group are cancer of the larynx and the intraoral lesions. It is in these groups, too, that late necrosis of the laryngeal cartilages or late osteonecrosis of the jaw has been reported. An attempt has been made here and by many other workers to use similar techniques in the irradiation of mammary cancer. It must be stated axiomatically that mammary cancer will not respond to small total doses of radiation, and that if any measurable response is to be obtained the tumor dose must be very large. The dose required is about 4,000 roentgens and possibly much higher. This brings us to dosage levels where extensive fractionation is necessary and also where late injuries to intervening and underlying structures can be expected. Injuries to the skin and the various phases of pleuropulmonary irradiation changes have been recorded. The case here reported is one of devitalization of the ribs and spontaneous multiple fractures occurring five to seven years after irradiation for mammary cancer.

The bone changes following heavy radiation are those of progressive fibrosclerosis with a resultant closing of the circulation in the haversian systems and the periosteal vessels. The bones become devitalized, brittle and fracture easily. Because of the bone death the fractures do not heal but they also are insensitive.

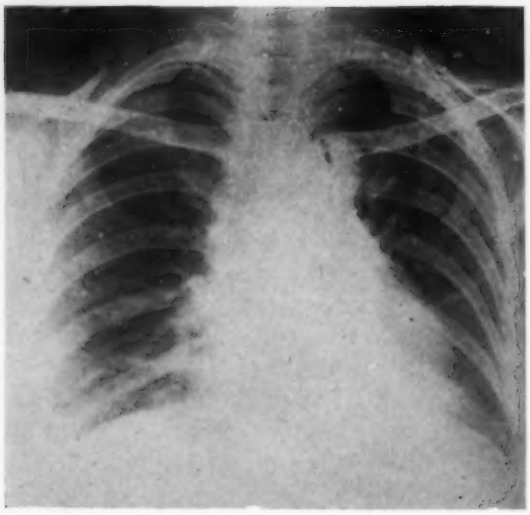

FIG. 1. Roentgenogram of the thorax June 29, 1938. Six radon seeds in the left supraclavicular fossa; otherwise negative.

CASE REPORT

Mrs. B.M., aged forty-eight, was referred to the Radiation Therapy Department October 19, 1934, for radiation therapy for cancer of the left breast. The tumor was of five weeks' known duration and was growing rapidly. Examination showed a mass in the upper outer quadrant of the left breast 3 cm. in diameter, not adherent to the skin or deeper structures. A second, larger mass was present in the anterior axillary and pectoral area measuring 5 by 6 by 3 cm. and adherent to the subcutaneous tissues but not to the chest wall. No supraclavicular nodes were palpable. The opposite breast and its gland bearing areas were negative. Roentgen examination of the skull, pelvis and lungs was negative. The menopause had occurred eight years previously. The case was considered operable and a course of preoperative roentgen therapy was given using the following factors: 200 kv., 0.5 mm. Cu plus 1.0 mm. Al filter, 50 cm. focal skin distance; anterior field covering the breast and the anterior axilla 15 by 15 cm.; posterior axillary field 10 by 10 cm.; supraclavicular field 6 by 8 cm. The dosage was 300 r given to each field five times, treating one field every second day. The total dosage was completed in thirty-five days. The tumor was very radiosensitive diminishing markedly in size before the completion of treatment. Radical amputation was done two weeks post-irradiation. Residual adenocarcinoma was found in the breast and pectoral lymph nodes.

Two months later a lymph node was palpable in the end of the mastectomy scar and also in the axilla. Roentgen therapy was repeated treating the axilla anteriorly, posteriorly and superiorly (through the supraclavicular space) much the same as during the cycle of preoperative irradiation, but carrying the total air measured dose to 1,200 r per field and completing the treatment in thirty-two days. The palpable lesion again diminished in size and the patient remained well without subjective or objective findings until one year after her first visit. In October, 1935, the mass in the humeral end of the mastectomy wound was again palpable and roentgen therapy was repeated using similar dosage as before. A punch biopsy of this nodule showed adenocarcinoma, of the breast infiltrating the skin.

Within one year the left upper thorax in this patient received 4,000 r to each of three fields. The irradiation was given directly to the chest areas. Had the preoperative irradiation been given tangentially, the ribs beneath the breast would have received a still larger dose. Furthermore the dosage used in 1934–1935 was considerably lower than that now used. Roentgenograms of the lungs and osseous system remained negative. There was no post-irradiation pleuropulmonary reaction.

In June, 1936, twenty months after the first treatment, supraclavicular metastases were palpable. Roentgen therapy to the supraclavicular fossa was instituted crossfiring that region

FIG. 2. Roentgenogram of the thorax November 13, 1939, showing fracture of the left third rib.

through anterior and posterior fields. Protracted fractionated treatment, Thoraeus filter equivalent to 2 mm. Cu plus 1 mm. Al was used; 100 r, measured in air, was given daily to each field, five treatments a week for a total of 3,000 r to each field, completed in forty-two days. A month later the supraclavicular lymph nodes were no longer palpable.

In February, 1937, twenty-eight months after her first visit the supraclavicular lymph nodes were again large. Roentgenograms were still negative for lung or osseous changes. The supraclavicular fossa and the axilla were again irradiated with daily fractions of 100 r for a total dose of 3,000 r but, because of the previous irradiation, the treatment time was protracted over a three month period. The metastatic nodes continued to grow larger in spite of the heavy irradiation. On June 30, 1937, six radon seeds of 1 mc. each were inserted into the mass. Three months later the mass was much smaller but six months after the insertion of the seeds, the mass continued to grow, the supraclavicular fossa was brawny, indurated and hard.

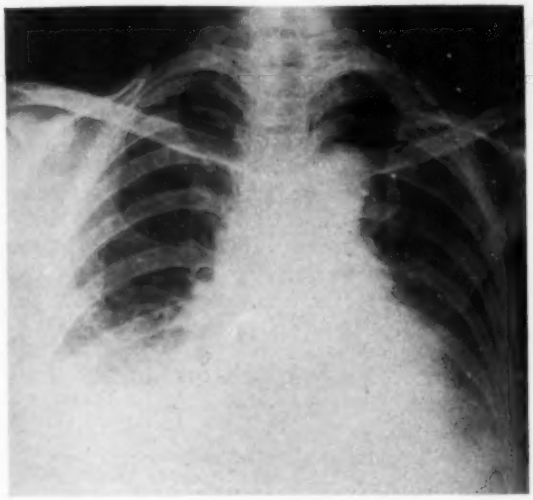

Fig. 3. Roentgenogram of the thorax February 20, 1940, showing fractures of the left third and fourth ribs.

The patient remained under observation without further treatment until November, 1939, five years after her first visit. Roentgen examination now showed a pathological fracture of the left third rib (Fig. 2). The skin began to show late irradiation changes, telangiectasis and induration. Because of these and the mildness of pain referable to the fracture no further treatment was used. On February 20, 1940, sixty-six months after the first treatment there were pathological fractures of the left third and fourth ribs (Fig. 3).

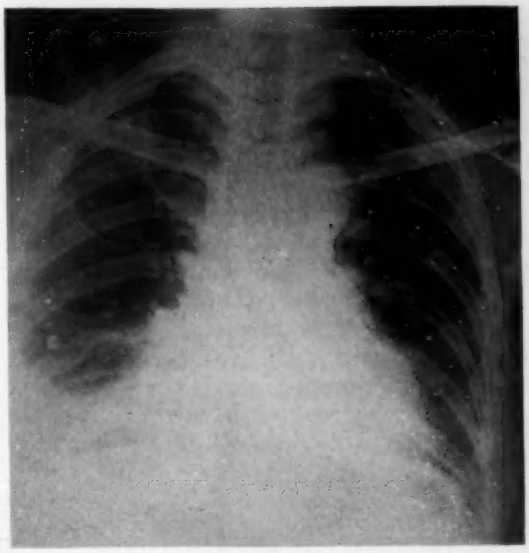

Fig. 4. Roentgenogram of the thorax December 23, 1940, showing fractures of the left third, fourth and fifth ribs.

On December 23, 1940, seventy-four months after the first treatment there were pathological fractures of the left third, fourth and fifth ribs (Fig. 4), and on December 29, 1941, seven years

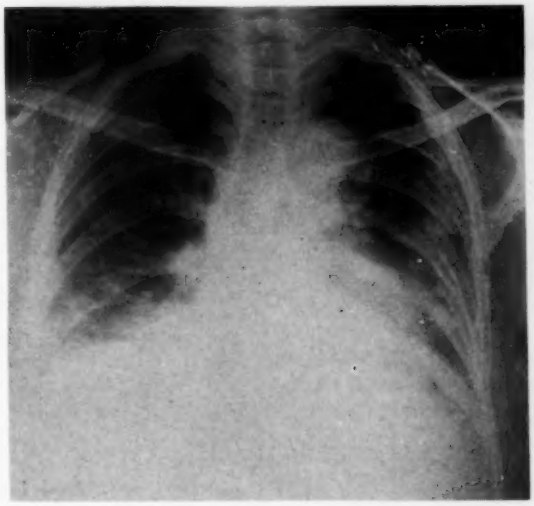

Fig. 5. Roentgenogram of the thorax December 29, 1941, showing fractures of the left second, third, fourth, fifth, sixth and seventh ribs.

and two months after the first treatment there were pathological fractures of the left second, third, fourth, fifth, sixth and seventh ribs (Fig. 5). There still are no symptoms referable to the rib fractures. There are pronounced motor and sensory disturbances of the left arm secondary to post-irradiation degenerative changes in the heavily irradiated brachial plexus. There are atrophic and telangiectatic changes in the irradiated skin areas. There are no distant metastases other than the persistent supraclavicular mass.

The rib fractures, the first one of now two years' known duration, show no tendency to heal. The bone structure shows thinning of the linear markings, decrease in density but none of the chewed-out appearance of metastatic infiltration. There is some rounding off or absorption of the fractured edges. This occurs slowly over a long period of time. There is no suggestion of new bone formation or callus. The picture is that of devitalized bone, brittle and fragmented. These fractures differ from the traumatic and metastatic type not only in their roentgenographic appearance but also in that they are practically symptom free.

SUMMARY

A case of adenocarcinoma of the breast with axillary and supraclavicular and local skin metastases has been heavily irradiated and the disease has remained arrested over a seven year period. As a sequel to the irradiation there are late degenerative changes in the brachial plexus, ribs and skin with benign pathological fractures of six ribs and motor and sensory disturbances of the arm.

REFERENCES

1. Baensch, W. Knochenschädigung nach Röntgenbestrahlung. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1927, *36*, 1245–1247.
2. Baker, L. D. Spontaneous fracture of the femoral neck following irradiation. *J. Bone & Joint Surg.*, 1941, *23*, 354–358.
3. Desjardins, A. U. Reaction of the pleura and lungs to roentgen rays. Am. J. Roentgenol. & Rad. Therapy, 1926, *16*, 444–448.
4. Downs, E. E. Lung changes subsequent to irradiation in cancer of the breast. Am. J. Roentgenol. & Rad. Therapy, 1936, *36*, 61–64.
5. Engelstad, R. B. Die Strahlenreaktion in den Lungen beim Menschen. *Acta radiol.*, 1937, *18*, 32–43.
6. Ewing, J. Radiation osteitis. *Acta radiol.*, 1926, *6*, 399–412.
7. McIntosh, H. C. Changes in lungs and pleura following roentgen treatment of cancer of the breast by prolonged fractional method. *Radiology*, 1934, *23*, 558–566.
8. Lüdin, M., and Werthemann, A. Lungenveränderungen nach experimenteller Röntgenbestrahlung. *Strahlentherapie*, 1930, *38*, 684–701.
9. Okrainetz, C. L., and Biller, S. B. Fracture of the neck of the femur complicating roentgen therapy of ovarian cancer. Am. J. Roentgenol. & Rad. Therapy, 1939, *42*, 883–887.
10. Strauss, H., and McGoldrick, J. L. Fracture of femoral neck following roentgen therapy for gynecologic malignancy. *Am. J. Obst. & Gynec.*, 1941, *41*, 915–934.
11. Watson, W. L., and Scarborough, J. E. Osteoradionecrosis in intraoral cancer. Am. J. Roentgenol. & Rad. Therapy, 1938, *40*, 524–534.
12. Widmann, B. P. Irradiation pulmonary fibrosis. Am. J. Roentgenol. & Rad. Therapy, 1942, *47*, 24–38.

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SPECIFIC ACTION OF POLONIUM ON THE LYMPHATIC SYSTEM AS SHOWN IN ADRENALECTOMIZED ANIMALS

By CHARLES PHILIPPE LEBLOND *and* ANTOINE LACASSAGNE
Department of Anatomy, McGill University, Montreal, and Institut du Radium, Paris

IT HAS been shown repeatedly that damaging agents, such as cold, trauma, toxic chemicals, and so forth, produce an atrophy of the thymolymphatic system in normal but not in adrenalectomized animals.[3,5,7] Therefore, the action of toxic agents on lymphatic organs is an indirect one, exerted for the most part through the adrenal glands.[3,4,5,7,8] There was a possible exception in the case of polonium since, in the body, this substance was localized in the lymphatic tissue,[1] and therefore might produce a lymphatic involution by a local destructive action rather than by a systemic toxic effect exerted through the adrenals. It was of interest to determine whether polonium would still bring about the involution of the thymolymphatic system in adrenalectomized animals.

Twenty adult female rats were subdivided into two control groups and two groups which were adrenalectomized three days previous to the polonium treatment. One group of normal and one group of adrenalectomized rats were given a single subcutaneous injection of 75 electrostatic units[1] of polonium per animal. The animals were sacrificed three days later. Body and organ weights were noted, and the fat content of the liver was examined by Laszt and Verzár's method.[2]

The results (Table 1) show an atrophy of the thymus and spleen after injection of polonium, not only in normal, but also in adrenalectomized rats. In addition, the general toxic effect of polonium was shown by the decreased body weight of all treated animals, a small increase in adrenal weight and in fat content of the liver in the treated intact animals, and superficial gastric ulcerations found in 2 of the 5 treated adrenalectomized animals.

In intoxications with other drugs, similar results were previously obtained except that adrenalectomy prevented both lymphatic involution[7] and fatty infiltration of the liver,[3,5] while in the case of polonium removal of the adrenals prevents only the

TABLE I

	Body Weight (gm.)		Adrenals (mg.)	Thymus (mg.)	Spleen (mg.)	Liver fat (per cent)	Gastric Ulcerations
	Before	After					
Normal controls	180	183	28 (24–31)	157 (127–215)	610 (458–713)	6.5 (5.9–7.1)	None
Normal + polonium	179	169	32.5 (30–37)	37 (33–47)	330 (215–417)	7.6 (6.7–8.2)	None
Adrenalectomized controls	172	171	—	142 (112–185)	513 (414–636)	5.7 (5.2–6.5)	None
Adrenalectomized + polonium	165	148	—	49 (34–69)	292 (219–387)	5.5 (4.9–5.8)	Small

The figures in parentheses indicate the extreme variations.

accumulation of fat in the liver. As far as was known, the only substances which could produce an involution of the thymolymphatic apparatus in adrenalectomized animals were steroid hormones,[8] especially estradiol and desoxycorticosterone acetate. The action of these steroids on the thymus was not as rapid and complete as that of polonium

Since the autograph method revealed the localization of polonium inside the reticular cells in lymphatic formations, it was assumed that the lymphocytes present in the meshes of the reticulum were within the path of action of the destructive α-rays emitted by polonium.[1] This would satisfactorily explain the atrophy of the lymphatic tissue in adrenalectomized animals treated with polonium, while in the similarly treated intact controls, the local effect and the nonspecific systemic effect combined to produce the lesions. On the other hand, since the α-rays from polonium are known to be readily absorbed by surrounding material, the tissues located at some distance from the polonium in the reticulum should remain unaffected by the radiation, contrary to what happens with, for instance, radioactive phosphorus. Furthermore, small doses of polonium appeared innocuous to the kidney and liver.[1] A clinical trial of polonium as a therapeutic agent for lymphatic leukemia appears to be indicated.

SUMMARY

Polonium is thus far the only non-hormonal substance known which may produce an involution of the thymolymphatic system in the absence of the adrenal glands.

REFERENCES

1. LACASSAGNE, A., LATTÈS, J., and LAVEDAN, J. Etude expérimentelle des effets biologiques du polonium introduit dans l'organisme. *J. de radiol. et d'électrol.*, 1925, *9*, 1–14; 67–82.
2. LASZT, L., and VERZÁR, F. Beeinflussung der Fettwanderung durch Jodessigsäure und Nebennierenexstirpation. *Biochem. Ztschr.*, 1936, *285*, 356–367.
3. LEBLOND, C. P. Le syndrome non spécifique (réaction d'alarme de Selye). *Ann. d'endocrinol.*, 1939, *1*, 179–196.
4. LEBLOND, C. P., and SEGAL, G. Action des toxiques sur le thymus de l'animal sans surrénale. *Compt. rend. Soc. de biol.*, 1938, *129*, 838–840.
5. LEBLOND, C. P., and SEGAL, G. Differentiation between the direct and indirect effects of roentgen rays upon the organs of normal and adrenalectomized rats. AM. J. ROENTGENOL. & RAD. THERAPY, 1942, *47*, 302–306.
6. LEBLOND, C. P., NGUYEN-VAN THOAI, and SEGAL, G. Infiltration graisseuse du foie sous l'action des agents nocifs. *Compt. rend. Soc. de biol.*, 1939, *130*, 1557–1559.
7. SELYE, H. Studies on adaptation. *Endocrinology*, 1937, *21*, 169–188.
8. SELYE, H. In: Brouha, L. Les hormones sexuelles. J. Hermann, Paris, 1938.

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MEASUREMENTS ON ROENTGEN-RAY PRODUCTION AND ABSORPTION IN THE RANGE 0.7 TO 2.5 MEGAVOLTS

By L. C. VAN ATTA,* A. A. PETRAUSKAS,† *and* F. E. MYERS‡
George Eastman Research Laboratory of Physics, Massachusetts Institute of Technology
CAMBRIDGE, MASSACHUSETTS

I. INTRODUCTION

THIS research is concerned with the intensity and quality of the continuous radiation produced at a thick target of high atomic number by bombardment with high energy electrons, and with the absorption of this radiation by various materials.[1] Such information has application in high voltage roentgen-ray research and therapy, and makes possible a limited comparison with existing theory.

Most previous precision measurements of absorption coefficients have been made with *homogeneous* radiation either at low voltage where homogeneous roentgen rays are obtainable by crystal reflection, or at high voltage as the homogeneous gamma rays from radioactive materials. Such measurements have been made in various materials up to 0.5 megavolts[2] with a probable error of 1 per cent, up to 2.5 mv.[3] with a probable error of 4 per cent, and in a few elements at isolated higher voltages[4] with less accuracy. Experiment and theory concerning the absorption of homogeneous radiation are in satisfactory agreement throughout the voltage range involved.

Measurements of the intensity and quality of the *heterogeneous* radiation produced at a thick target have been made up to 0.5 mv., and to a limited extent up to 1.0 mv. In the low voltage range the efficiency of production of roentgen rays, the angular distribution of the radiation from thin targets, and the absorption coefficients in various materials have been measured with considerable precision. In the region between 0.5 and 1.0 mv., where characteristic radiation no longer plays an important part, much remains to be done. The variation of the intensity of heavily filtered radiation with angle has been determined at 0.5 mv.[5] The dependence of intensity on thickness in various absorbers has been measured for the heterogeneous radiation produced at voltages up to 1.0 mv.[6]

The theoretical problem of describing the continuous radiation produced at high voltage in a thick target of high atomic number is too complicated for exact solution. However, existing theory does permit certain qualitative predictions concerning the angular distribution of the radiation and also a calculation within the accuracy of this experiment of the absorption coefficients for the heterogeneous radiation and the efficiency of roentgen-ray production. The various aspects of the theory will be discussed in connection with the experimental results with which they are to be compared.

[1] Rough preliminary results were presented earlier: Van Atta, L. C., and Northrup, D. L. Measurements of roentgen-ray production in the range of 0.8 to 2.0 million volts. Am. J. Roentgenol. & Rad. Therapy, 1939, *41*, 633–636; present authors, *Phys. Rev.*, 1941, *59*, 688A.

[2] Read, J., and Lauritsen, C. C. *Phys. Rev.*, 1934, *45*, 433.

[3] Chao, C. Y. *Phys. Rev.*, 1930, *36*, 1519; Tarrant, G. T. P. *Proc. Roy. Soc.*, 1930, *A128*, 345.

[4] Delsasso, L. A., Fowler, W. A., and Lauritsen, C. C. *Phys. Rev.*, 1937, *51*, 391.

[5] Corrigan, K. E., and Cassen, B. Spatial distribution of radiation from a supervoltage roentgen tube and its significance in therapy. Am. J. Roentgenol. & Rad. Therapy, 1937, *37*, 811–818.

[6] Phillips, R., and Innes, G. S. Physical measurements in high voltage x-ray therapy. *Brit. J. Radiol.*, 1938, *11*, 498–503; Hudson, J. C. Physical measurements on roentgen radiation from tube actuated by Van de Graaf generator. *Radiology*, 1939, *32*, 530–537. Also Folsom, Stone, Rose, Bouwers, and Hermann and Jaeger.

* Now in the Electrical Engineering Department, Massachusetts Institute of Technology, Cambridge, Massachusetts.
† Now in the Physics Department, University of Notre Dame, Notre Dame, Indiana.
‡ On leave from the Physics Department, New York University, University Heights, and now at the Frankford Arsenal, Philadelphia, Pennsylvania.

The present research is concerned with the following specific problems:

1. Measurement of the total mass absorption coefficient in lead as a function of voltage and filter thickness, and in tin, copper, aluminum, carbon and water as a function of voltage. A lead filter sufficient to achieve approximately the final steady value of absorption coefficient was used.

2. Measurement of the relative intensity of the radiation and the final absorption coefficient in lead as a function of angle at several voltages.

3. Measurement in the forward direction of the absolute intensity of the total radiation as a function of voltage. These absolute intensity measurements, besides their practical usefulness, can be combined with information concerning the angular distribution to calculate approximately the efficiency of production of roentgen rays as a function of voltage.

II. APPARATUS

The general scheme is to make intensity measurements in a severely collimated roentgen-ray beam by means of an air-equivalent thimble chamber. (Throughout the paper the term "intensity" refers to the reading of an air-equivalent thimble chamber.) The collimation serves to define the angle with respect to the direction of the original electron beam, to exclude roentgen rays scattered in the absorber, and to exclude the background of roentgen rays scattered from various parts of the room. By varying the direction of the axis of the collimator with the roentgen-ray target as a center, the intensity or the absorption coefficient of the radiation can be measured as a function angle. Figure 1 shows the roentgen-ray target, the collimator, the thimble chamber, and the aluminum structural frame which supports the collimator.

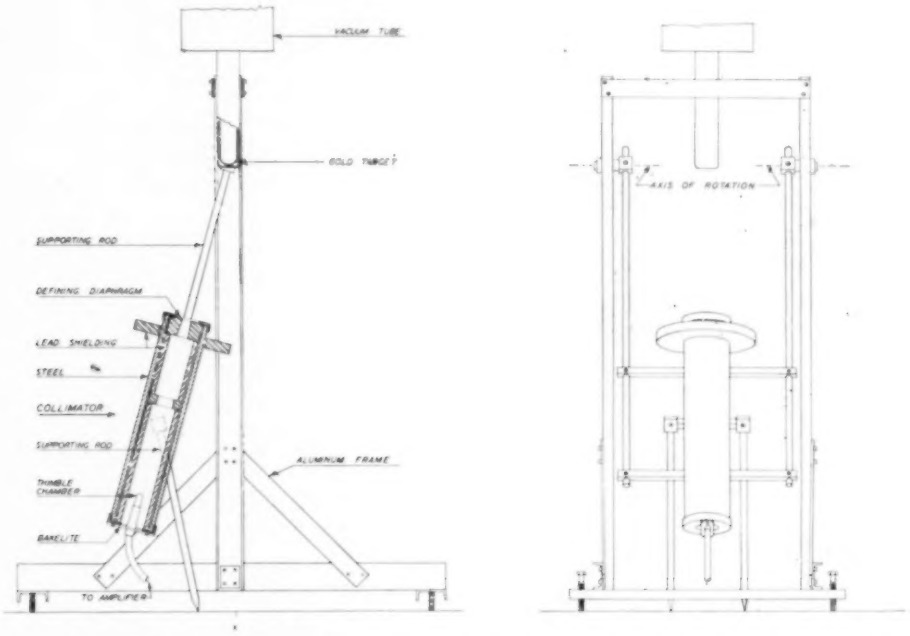

FIG. 1. General view of the roentgen-ray target, collimator and thimble chamber, and the structural frame supporting the collimator.

The details of the collimator itself are shown in Figure 2. At a distance of about 50 cm. from the target is placed the heavy defining diaphragm which consists of a disk of lead 5 cm. thick with a hole 2.5 cm. in diameter. A 3° taper on this hole prevents the concentrating effect obtained on the axis by small angle scattering from a cylin-

drical wall. The second diaphragm serves to a certain extent to protect the walls in the lower part of the collimator from radiation scattered by the first diaphragm and to protect the thimble chamber from radiation from the walls of the upper part of the collimator. The walls of the collimator are 2.5 cm. thick, half lead and half steel. This thickness is sufficient to protect the thimble chamber from background radiation scattered from various parts of the room. Back-scattered radiation into the open lower end of the collimator is low because of the distance (approximately 3 meters in the forward direction) to the nearest heavy scattering material, and is further reduced by a lead collar (2.5 cm. in thickness by 30 cm. in diameter) which casts a shadow on objects behind the collimator, and by a lead skirting (3 mm. thick by 20 cm. in length, not shown in the figure) added to the lower end of the collimator. In Figure 2 construction lines show the extent of the roentgen-ray beam. It is evident that all parts of the thimble see all parts of the target spot (1.3 cm. diameter), and that the inner walls of the collimator are protected against direct radiation from the target.

The collimator thus constructed was subjected to two performance tests. Absorption measurements in lead for thicknesses up to 10 cm. were made with 2.5 and 1.3 cm. diameter defining diaphragms. The resulting curves (I/I_0 versus absorber thickness) were identical, showing that the 2.5 cm. diameter diaphragm provided sufficient collimation. Likewise as the thickness of lead absorber was further increased to 15 cm. the roentgen-ray intensity at the thimble chamber approached zero exponentially. This shows that the background radiation inside the collimator was negligible.

The thimble chamber was adopted for the measurement of roentgen-ray intensity on the basis of considerable previous experimental[7] and theoretical[8,9] work. This work has shown that the thimble chamber is the only practicable method for measuring radiation above 0.4 mv., that measurements made by different observers with chambers of different geometries and different "air-equivalent" wall materials are accurately comparable, and that the corrections for wall effect necessary to reduce reading to roentgens, according to the accepted definition, are small and calculable.[8] An "air-equivalent" wall material is one in which the roentgen-ray beam has the same equilibrium complement of electrons as it has in air. Theoretically the wall thickness should be at least as great as the range of secondary electrons in the material[9] if the chamber is to be used in a collimated beam, but experimentally the wall thickness can be somewhat less than this. In the case of carbon which is the element most nearly

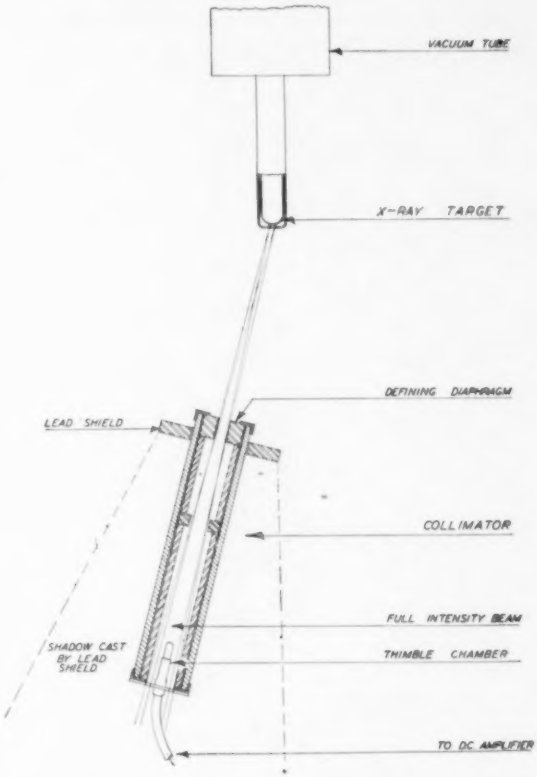

Fig. 2. Detailed view of the collimator showing the definition of the roentgen-ray beam.

[7] Glasser, O., and Rovner, L. Dosimetry in radiation therapy; gamma-ray measurements in roentgens. Am. J. Roentgenol. & Rad. Therapy, 1936, *36*, 94–104; Taylor, L. S., Singer, G., and Charlton, A. L. Measurement of supervoltage x-rays with the free-air ionization chamber. Am. J. Roentgenol. & Rad. Therapy, 1939, *41*, 256–275; and others.

[8] Laurence, G. C. *Canad. J. Research*, 1937, *15A*, 67.

[9] Gray, L. H. *Proc. Roy. Soc.*, 1936, *A156*, 578.

air-equivalent, the correction factor to obtain equivalent roentgens from the actual readings is 1.023 in the case of gamma rays from radium in equilibrium with its decay products, and is 1.027 in the case of the total radiation at 0.6 mv. Thus the roentgen-ray intensity measured by a carbon-wall thimble chamber in the energy region from 0.6 to 2.5 mv. may be written $r = 1.025(I/V)$ roentgens per minute; where I = ionization current (stat-coulombs per minute) V = volume of chamber (cc).

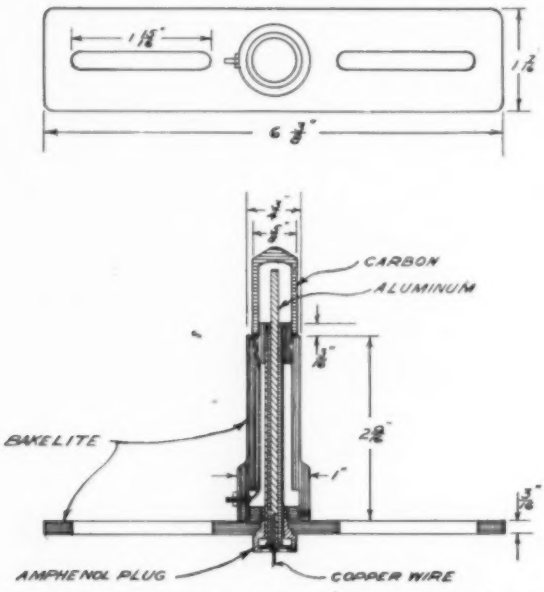

FIG. 3. Detailed view of the carbon-walled thimble chamber with its mounting strap.

The thimble chamber used in these experiments is shown in cross section in Figure 3, with a mounting strap for fastening the chamber to the lower end of the collimator. The volume of the chamber is 1.94 cc. and the wall thickness is 2.4 mm. on the sides. Sweep voltage is applied to the carbon thimble by means of a wire leading to the side binding post. Ionization current is collected on the central aluminum wire and conducted to an amplifier. An aluminum tube connecting to the cable shield acts as a guard ring to reduce the effective leakage current. Saturation voltage for high roentgen-ray intensities proved to be 270 volts.

This thimble chamber was subjected to several performance tests. The wall thickness was increased by factors of 2 and 3 with no appreciable change in intensity reading either for 0.9 mv. unfiltered radiation or for 2.2 mv. heavily filtered radiation, except for the small absorption in the wall itself. Next, the chamber with the single wall thickness was used to measure radiation from a lead-bakelite filter. The reading of the chamber was not affected by the order of the lead and bakelite in the filter. However, a 6 mm. disk of bakelite was inserted into the collimator just below the defining diaphragm to insure that the roentgen-ray beam in the collimator was in air equilibrium under all conditions. Then a comparison was made between the carbon wall thimble chamber and a standard Victoreen 25 r thimble chamber for various conditions of voltage and filtration. The Victoreen reading was about 5 per cent higher than the carbon thimble at 0.9 mv. and no filtration but gradually fell with increasing voltage and filtration to a value about 15 per cent lower than the carbon thimble for 2.2 mv. and heavy filtration. This trend was to be expected because of the thinner wall of the Victoreen chamber, and was largely eliminated by fitting the Victoreen chamber with additional wall thickness of bakelite. Finally, the carbon thimble chamber was used both longitudinally in the beam (as shown in the various figures) and transversely to test the effect on its reading, of radiation scattered back from the base of the chamber. No detectable difference in reading was found, as is not surprising in this voltage range when the small amount of light material involved is considered.

The ionization produced in the carbon thimble chamber was measured with a current amplifier rather than by a condenser discharge method, in order to have a continuous reading of roentgen-ray intensity and to avoid the necessity of maintaining constant conditions.

The construction of the target is shown in detail in Figure 4. Because of its effect

on the unfiltered intensity in the forward direction and especially on the relative intensity as a function of angle, the lead equivalent target thickness at 1.2 mv. is given on the figure for several indicated directions. It is evident that much greater absorption must be expected in the neighborhood of 90° and that this effect must be considered in connection with angular distribution curves. Gold was chosen as the target material because it is the element of largest atomic number practicable for such use. The thickness used was required both for strength and for stopping the high speed electrons. An earlier target[1] of lead electroplated onto copper was not satisfactory because of a tendency of the lead to evaporate away from the target spot.

For the absorption coefficient measurements the absorber consisted of disks of the pure material 10 cm. in diameter and each of such thickness as to reduce the intensity by 30 to 50 per cent. In the case of water, distilled water of known temperature was used in a 15 cm. diameter glass cylinder accurately marked for depth. The total thickness of absorber, in addition to a lead pre-filter, varied from 10 cm. in the case of lead to 30 cm. in the case of water. The densities of the various absorbing materials, except for water, were measured by weighing a known volume.

A steady d.c. voltage and a constant, well focused beam of electrons were provided by a belt electrostatic generator and an accelerating tube recently described.[10]

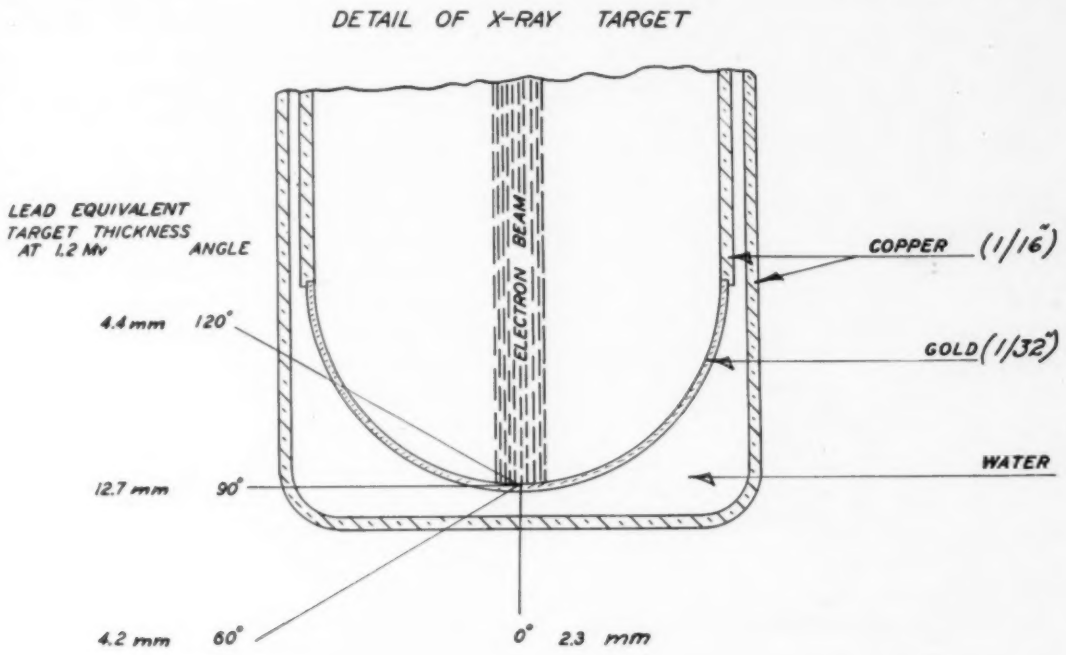

Fig. 4. Details of the roentgen-ray target construction showing the lead-equivalent target thickness at various angles.

III. Measurement of Absorption Coefficients

For the measurement of absorption coefficients in the forward direction, thimble chamber intensity readings in the collimated beam were taken as a function of thickness of absorber placed above the defining diaphragm. For these measurements the voltage was maintained very constant (±0.2 per cent) and the electron beam current, corresponding to each roentgen-ray

[10] Van Atta, L. C., Northrup, D. L., Van de Graaff, R. J., and Van Atta, C. M. *Rev. Sc. Instruments*, 1941, *12*, 534.

intensity measurement, was recorded. Such measurements were taken with increasing absorber thickness until the intensity became too small to read accurately, then with a much larger thickness to establish the small zero reading, and finally with decreasing absorber thickness to correct any systematic trends in error. Comparable relative intensity readings were obtained by dividing each intensity reading by the corresponding electron current, making the zero correction, averaging the results obtained with increasing and decreasing filter thickness, and dividing successive intensity values by the initial value.

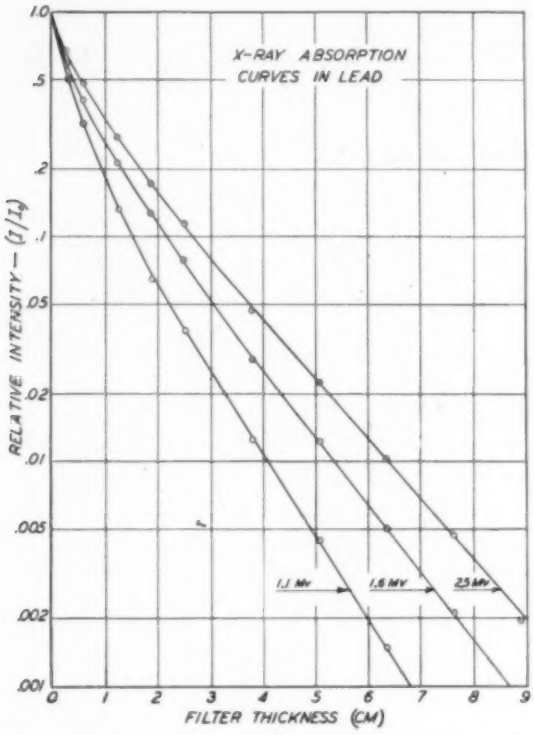

FIG. 5. Absorption curves in lead for the radiation produced at various voltages.

When such relative intensity (I/I_0) values are plotted against filter thickness on semi-logarithmic paper the slope of the resulting curve provides a measure of the total mass absorption coefficient,

$$\mu_m = ln(I_0/I)/\rho x$$

where μ_m = total mass absorption coefficient (cm²/gram), ρ = density of absorber (grams/cc), x = absorber thickness (cm). Curvature in the initial part of these curves is an indication of a decreasing absorption coefficient due to the selective absorption of the softer components in the heterogeneous radiation. After sufficient filter has been used the wave length range of the radiation in the beam becomes so narrow that the corresponding absorption coefficient is approximately constant. The resulting straight line portion of the curve permits an accurate determination of the final constant value of absorption coefficient.

Typical absorption curves are shown in Figure 5, which gives the absorption in lead of the radiation produced at various voltages. It appears that the absorber thickness necessary for establishing the equilibrium condition increases with voltage, but that the final slope is constant over a wide range of absorption. This is more evident in Figure 6, in which the mass absorption coefficient obtained from the slope of the logarithmic curves is plotted against filter thickness for the radiation produced at several voltages. From Figure 6 we see that the initial absorption coefficient at each voltage is approximately twice the final absorption coefficient and that the filter thick-

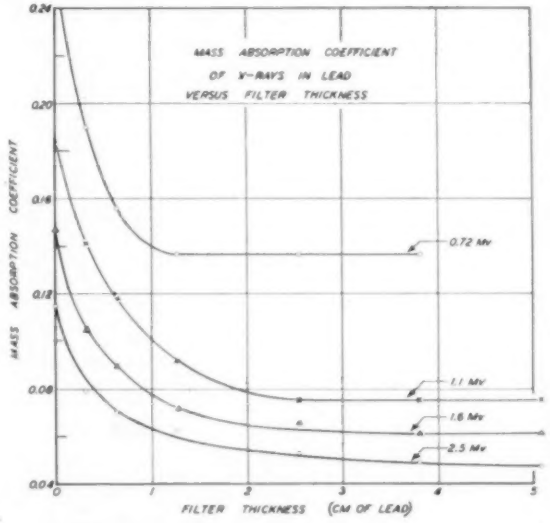

FIG. 6. Mass absorption coefficient in lead versus filter thickness for the radiation produced at various voltages.

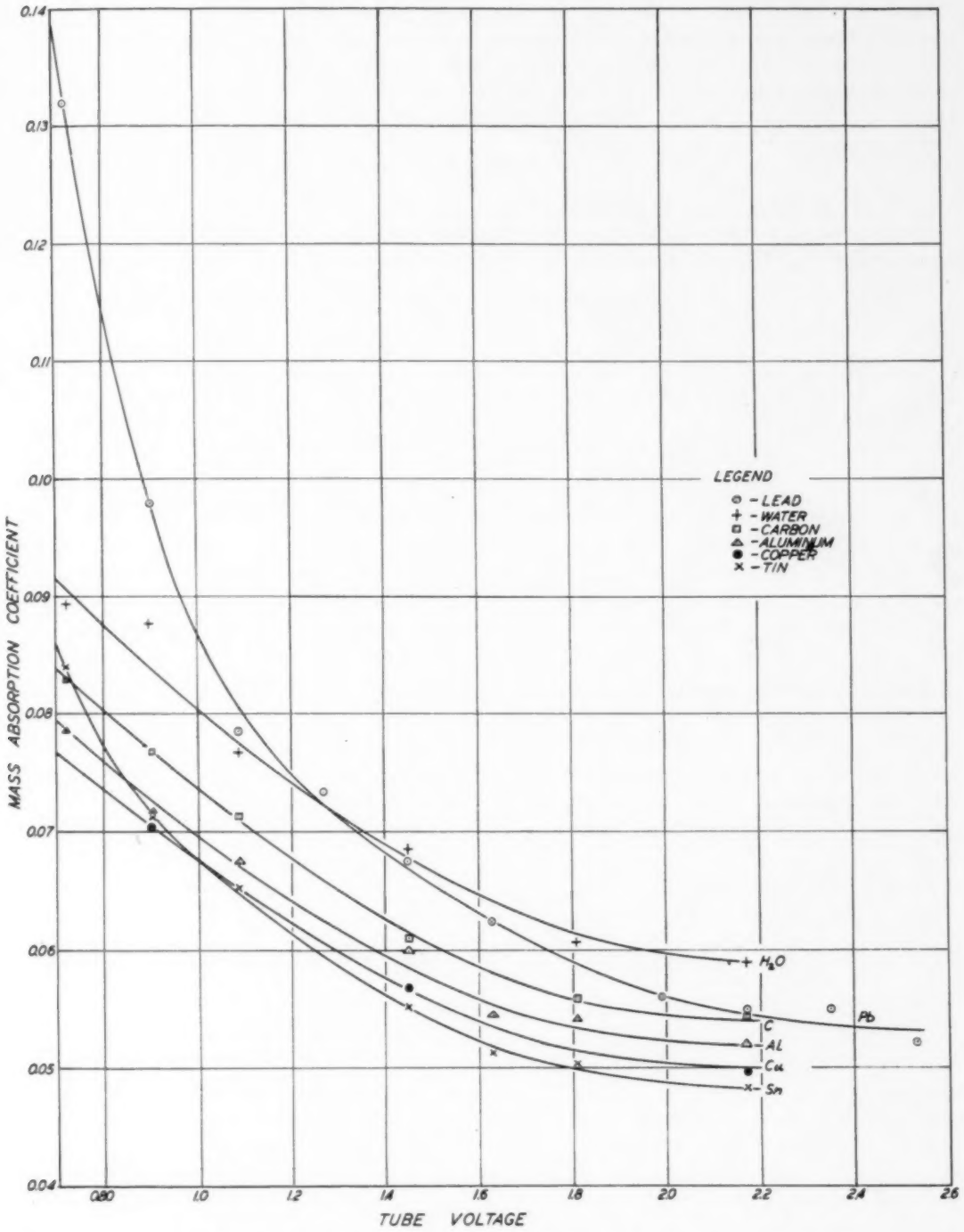

Fig. 7. Experimental values for the mass absorption coefficient in several materials of heavily filtered heterogeneous radiation plotted as a function of the tube voltage.

ness necessary for obtaining the equilibrium condition is roughly proportional to the voltage.

In Figure 7 is given the variation with voltage of the final value of absorption coefficient for several absorbing materials.

TABLE I

MASS ABSORPTION COEFFICIENT FOR HEAVILY FILTERED CONTINUOUS RADIATION IN VARIOUS MATERIALS AND AT SEVERAL TUBE VOLTAGES

Voltage (mv.)	Mass Absorption Coefficient (cm^2/gm)					
	Lead	Tin	Copper	Aluminum	Carbon	Water
0.72	0.132 ±0.005	0.0840 ±0.0025		0.0786 ±0.0020	0.0829 ± .00025	0.0893 ±0.0027
0.90	0.0979 ±0.0025	0.0714 ±0.0021	0.0704 ±0.0028	0.0717 ±0.0022	0.0768 ±0.0031	0.0886 ±0.0035
1.09	0.0876 ±0.0024	0.0653 ±0.0013		0.0675 ±0.0014	0.0713 ±0.0018	0.0768 ±0.0023
1.27	0.0734 ±0.0029					
1.45	0.0675 ±0.0020	0.0552 ±0.0014	0.0568 ±0.0023	0.0600 ±0.0012	0.0610 ±0.0012	0.0685 ±0.0021
1.63	0.0624 ±0.0016	0.0513 ±0.0021		0.0545 ±0.0022		
1.81		0.0504 ±0.0020		0.0541 ±0.0014	0.0588 ±0.0022	0.0607 ±0.0018
1.99	0.0560 ±0.0022					
2.17	0.0540 ±0.0017	0.0483 ±0.0015	0.0496 ±0.0020	0.0520 ±0.0016	0.0544 ±0.0016	0.0590 ±0.0018
2.35	0.0550 ±0.0022					
2.53	0.0522 ±0.0021					

The curves are drawn through the experimental points without regard to theory. In the case of absorbers other than lead a sufficient thickness of lead pre-filter was used to establish approximately the equilibrium condition. The thicknesses of lead pre-filter used at various voltages are 1.27 cm. for 0.72 to 1.1 mv., 2.54 cm. for 1.27 to 1.6 mv., and 3.81 cm. for 2.0 to 2.2 mv. There is some evidence that the equilibrium condition is established in the lighter elements with less filtration than in the case of lead.

The data presented in Figure 7 and Table 1 represent the summary of approximately 1,600 intensity readings on 83 absorption curves. Thus each of the 39 plotted points represents an average of 2.1 determinations. For each absorption curve an estimated probable error in the slope can be obtained by considering the spread in the curves which might reasonably be used to represent the points. Such estimated probable errors for individual curves (i.e., for individual determinations of absorption coefficient) ranged from 0.3 per cent to 4 per cent with an average value of 1.2 per cent. Where several determinations of a single absorption coefficient were made, a further measure of the probable error in the final result was imposed by the internal consistency of the several determinations. These considerations gave the probable errors listed in Table 1.

It is evident from Figure 7 that in four of the curves (H_2O, C, Al, and Cu) the same type of absorption is present, whereas in two of the curves (Pb and Sn) there is an additional absorption which becomes important at low voltage. In the higher part of the voltage range the order of increasing mass absorption coefficients (excepting Pb) is Sn, Cu, Al, C, and H_2O.

If the total absorption of energy from the roentgen-ray beam is considered to be due to true absorption and scattering by free electrons (Compton absorption and scattering),[11] absorption by bound electrons (photoelectric absorption),[12] and absorption due to the production of positron-electron pairs (pair production),[13] the total mass absorption coefficient may be written $\mu=\sigma+\tau+\kappa$. In this expression

$$\sigma=Z\cdot\frac{N}{M}\,\frac{2\pi e^4}{m^2c^4}\left[\frac{1+\alpha}{\alpha^2}\left\{\frac{2(1+\alpha)}{1+2\alpha}-\frac{1}{\alpha}\ln(1+2\alpha)\right\}+\frac{1}{2\alpha}\ln(1+2\alpha)-\frac{1+3\alpha}{(1+2\alpha)^2}\right],$$

[11] Klein, O., and Nishina, Y. *Ztschr. f. Phys.*, 1929, *52*, 853.

[12] Hulme, H. R., McDougall, J., Buckingham, R. A., and Fowler, R. H. *Proc. Roy. Soc.*, 1934, A *146*, 83; Jones, M. T. *Phys. Rev.*, 1936, *50*, 110.

[13] Bethe, H., and Heitler, W. *Proc. Roy. Soc.*, 1934, A *146*, 83.

where $\alpha = h\nu/mc^2$. $\tau \simeq Z^4\lambda^3 \times$ (a constant) or, empirically in the case of lead,[12]

$$\log_{10}\tau = \bar{4}.6882 + 1.03\log_{10}\lambda + 0.44(\log_{10}\lambda)^2.$$

$\kappa = Z^2 \cdot F_{(h\nu)} \times$ (a constant), where $F_{(h\nu)}$ must be obtained by numerical integration in this voltage range. The mass absorption coefficient for homogeneous radiation in lead and aluminum, as calculated from these expressions, is plotted as a function of voltage in Figure 8.[14] The several components of the total absorption coefficient are shown so that the absorption coefficients of elements of different atomic number can be estimated from the curves, by allowing for the variation of each component with atomic number.

The curves of Figure 8 for homogeneous radiation are in qualitative agreement with the experimental results for heterogeneous radiation presented in Figure 7. Photoelectric absorption and pair production are appreciable in this voltage range only for lead and tin. Photoelectric absorption explains the steeper rise in the lead and tin

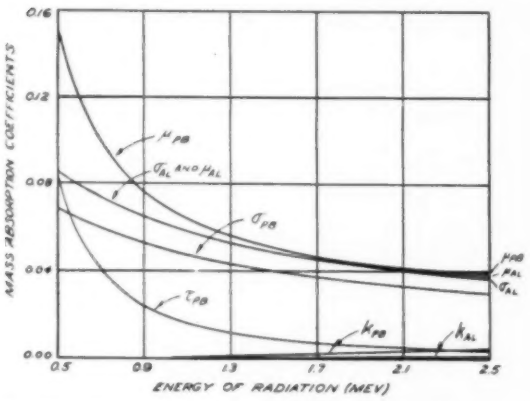

Fig. 8. Mass absorption coefficients for homogeneous radiation in lead and aluminum.

curves of Figure 7 at the low voltage end, and is appreciable throughout the entire voltage range in the case of lead. With the exception of lead, the absorption coefficient in the middle part of the voltage range is almost entirely due to Compton effect and therefore should be proportional to the number of electrons per gram of absorber, as is found experimentally to be the case. At the high voltage end, pair production is responsible for about 12 per cent of

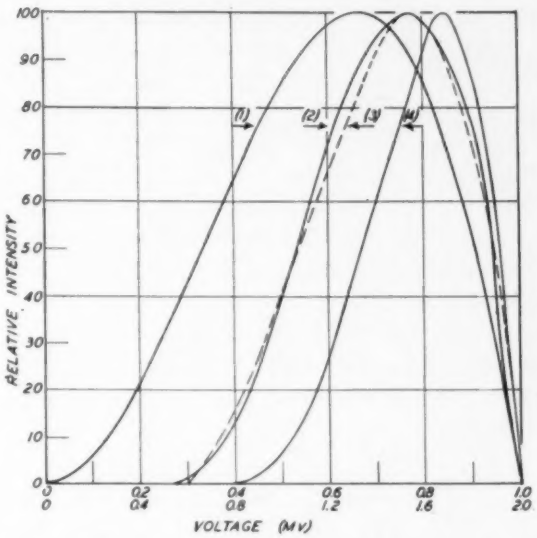

Fig. 9. Distribution in voltage of unfiltered (1) and filtered (2), (3), (4) radiation assuming Kramers' law and accepted values for lead absorption coefficients.

the absorption in lead and 7 per cent in tin. For the other elements this figure is less approximately in proportion to the atomic number.

It appears, therefore, that the measured absorption coefficients for heterogeneous radiation are in satisfactory qualitative agreement with the accepted theoretical expressions for homogeneous radiation. In order to make a more nearly quantitative comparison it is necessary to know the distribution in wave length of the heterogeneous radiation. Kramers' theory[15] yields the relation

$$I_V = \text{constant} \cdot V^2(V_0 - V)$$

where V_0 = tube voltage. This relation was used to obtain curve (1) in Figure 9 for the distribution in voltage of the unfiltered radiation produced either at 1.0 or 2.0 mv. The change in the shape of this curve as

[14] For the calculation of absorption by pair production and for the general method of presenting the curves we are indebted to R. D. Evans, "Introduction to the Atomic Nucleus," Massachusetts Institute of Technology Course Notes.

[15] Kramers, H. A. *Phil. Mag.*, 1923, *46*, 836.

the result of lead filtration can be calculated by using accepted values for the absorption coefficient of homogeneous radiation in lead at the different voltages. Curves (2) and (3) were obtained by assuming the thicknesses of lead pre-filter actually used at 1.0 and 2.0 mv., respectively, in measuring the absorption coefficients of other materials. From these curves it appears that the distribution of the radiation after prefiltering was very similar in the two cases. Curve (4) gives the distribution of the radiation produced at 2.0 mv. and filtered through 11.5 cm. of lead. From curves (1), (3), and (4), together with accepted values for the absorption coefficient of homogeneous radiation in a given material, it is possible to calculate the absorption coefficient in that material of the heterogeneous radiation produced at 2.0 mv. and filtered through 0, 3.8, and 11.5 cm. of lead. The results of these calculations for lead and aluminum absorbers are compared with the experimental values in Table II.

TABLE II

CALCULATED AND MEASURED VALUES FOR THE MASS ABSORPTION COEFFICIENT IN LEAD AND ALUMINUM OF THE HETEROGENEOUS RADIATION PRODUCED AT 2.0 MV., AFTER VARIOUS AMOUNTS OF LEAD FILTER

Thickness of Lead Filter (cm.)	Mass Absorption Coefficient (cm^2/gm)			
	Lead		Aluminum	
	Calculated	Measured	Calculated	Measured
0	0.090		0.059	
3.8	0.054	0.056	0.052	0.052
11.5	0.050		0.048	

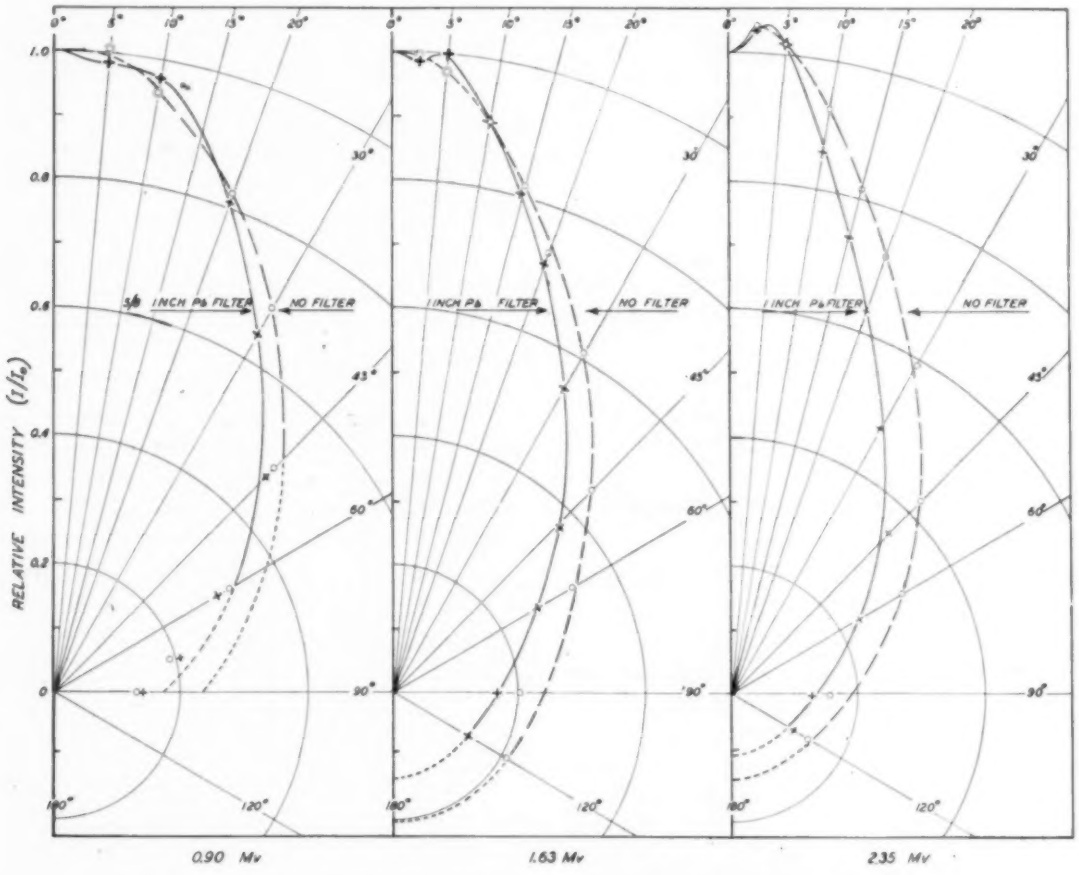

FIG. 10. Variation of intensity with angle for the unfiltered and filtered radiation at three values of tube voltage.

These calculations show the same effect of lead filter on heterogeneous radiation as was observed experimentally, i.e., that the initial high absorption coefficient in lead is reduced to roughly half value and then becomes approximately constant as the filter thickness is further increased. The absorption coefficient at small filter thicknesses was not determined accurately because of its rapid change with absorber thickness, but the high initial absorption observed is in qualitative agreement with the calculated value. There was not sufficient intensity left after 11.5 cm. of lead filter to permit an accurate measurement of the absorption coefficient of the resulting radiation, but no appreciable change in absorption coefficient was observed for lead thicknesses between 3.8 and 11.5 cm. The calculated and measured values for both lead and aluminum absorbers after 3 8 cm. of lead filter are in very satisfactory agreement. This agreement tends to confirm the values for the absorption coefficient of homogeneous radiation and to indicate that the distribution function given by Kramers' theory represents a reasonable approximation in spite of its theoretical limitations. Furthermore it tends to justify the method outlined above for calculating the absorption coefficient of the heterogeneous radiation in a severely collimated beam of roentgen rays produced at a given tube voltage and subjected to a given amount of filtration.

IV. MEASUREMENT OF ANGULAR DISTRIBUTION

To measure the roentgen-ray intensity as a function of angle with respect to the forward direction of the electron beam, the collimator was pivoted in its support to swing about the roentgen-ray target as a center (Fig. 1). The thimble chamber in the collimated beam then provides an approximately true measure of the intensity as a function of angle. The collimated beam also permits insertion of absorbing material into the beam to obtain a measure of the quality of the radiation as a function of angle.

With the tube voltage held constant the collimator was set at various angles, and the intensity and electron current were recorded. The intensity readings were divided by the corresponding electron currents and by the specific intensity in the forward direction to obtain comparable relative intensity readings. This procedure was followed with no filter and with a heavy lead filter for three values of tube voltage.

The results of the angular intensity measurements are presented in Figures 10 and 11. All these curves show the strong predominance of the radiation in the forward direction. The intensity ratio between 0° and 90° varies from 4.2 for the unfiltered radiation at 0.90 mv. to 7.3 for the filtered radiation at 2.35 mv. No attempt was made to pass these curves

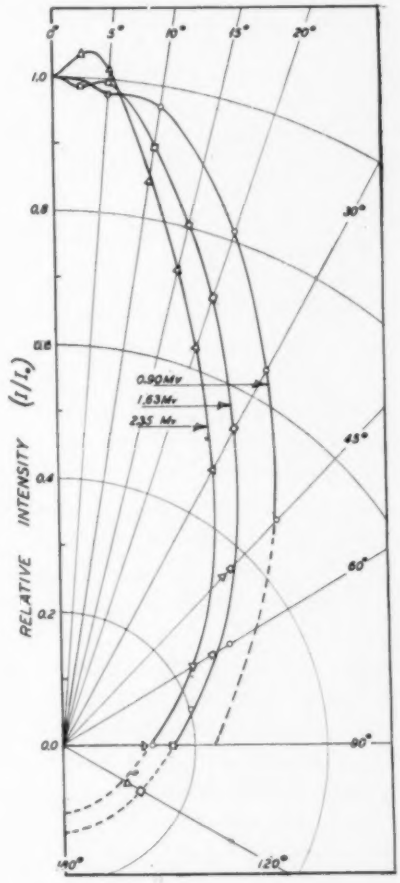

FIG. 11. Variation of intensity with angle for the filtered radiation at three values of tube voltage.

through the 90° experimental points because of the excessive absorption introduced by the target in that direction (see Fig. 4).

In Figure 10 the unfiltered and filtered relative intensity values are compared for three values of tube voltage. This comparison shows that the radiation is considerably softer at larger angles. The softening of the unfiltered radiation with increasing angle is an effect which increases with voltage, as is shown by Figure 12 in which the ratio of unfiltered to filtered relative intensities is plotted against angle for three values of tube voltage. The ratios have been adjusted to unity at the angle at which the radiation is hardest, rather than at 0°. These curves of an arbitrarily defined quantity are presented primarily because of the way in which they emphasize the angle of maximum hardness of the radiation (see Table III).

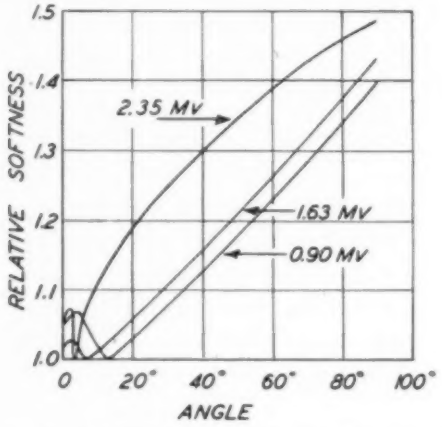

FIG. 12. Relative softness of the radiation produced at several voltages as a function of angle. These curves are presented to emphasize the angle of maximum hardness of the radiation (see Table III).

In Figure 11 the relative intensities of the filtered radiation for three tube voltages are compared. The amount of filtration used in these angular distribution measurements at each voltage was enough to realize approximately the equilibrium value of absorption coefficient: 1.6 cm. at 0.90 mv., 2.5 cm. at 1.63 mv., and 2.5 cm. at 2.35 mv. The comparison between the curves for the filtered radiation shows clearly the increasing concentration of the radiation in the forward direction as the voltage is increased.

A detailed examination of these curves at small angles reveals an interesting fine structure. There is a maximum in the curves which becomes more pronounced and which moves in to smaller angles as the voltage is increased. This effect is so small at 0.90 and 1.63 mv. that the small angle points on these curves were taken with great care. The 5° and 10° points on the 0.90 mv. curve and the 2.5° and 5° points on the 1.63 mv. curve were each obtained by repeated comparisons with the 0° intensity until this effect was definitely established. The additional maximum at 0° on the 0.90 and 1.63 mv. curves can be explained by assuming that the theoretical angular distribution patterns on the two sides of the axis have been widened for various reasons and caused to overlap in the forward direction. It is therefore assumed to be of no especial theoretical interest.

The angular positions of the intensity maximum at the several voltages as obtained from Figure 10 are given in Table III. Examination of the curves shows that the maximum moves in to smaller angles as the voltage is increased, but for a given voltage the harder components of the radiation have their maxima at larger angles. If these curves are thought of as the combination of two slightly overlapping angu-

TABLE III

ANGULAR POSITION OF THE INTENSITY MAXIMUM AT SEVERAL TUBE VOLTAGES

Voltage (mv.)	Positions of the Intensity Maximum			Positions of Hardness Maximum (Fig. 12)
	Unfiltered radiation	Filtered radiation	Sommerfeld theory	
0.90		9.0°	13	13
1.63	4°	4.5°	8	7
2.35	3°	3.5°	6	4

lar distribution patterns on opposite sides of the axis, resolving the lobes would increase appreciably the angle of the maximum.

The dependence of roentgen-ray quality on angle for the heavily filtered radiation from a thick target was obtained by measuring the final value of the mass absorption coefficient in lead at a number of angles with a fixed tube voltage. The dependence on angle of this absorption coefficient is given in Figure 13 for the radiation produced at 1.09 and at 1.63 mv. A pronounced dip in the curves at about 7° is followed by a regular rise as the angle is further increased. These curves illustrate the advantage of working in the forward direction rather than at 90° when penetrating radiation is required, and the additional advantage of working at a small angle from the forward direction if a small portal is used.

There is no available theory strictly applicable to the problem of calculating the angular distribution of the radiation produced in a thick target of high atomic number at high voltage. This is not surprising in view of the extreme difficulties imposed by these conditions. Sommerfeld's classical theory[16] is relativistic but assumes a thin target and complete stopping of the electron without change in direction. His wave mechanical theory[17] is non-relativistic and therefore not applicable. Later theories[13,18] are much too complicated to justify calculation, especially in view of the fact that they represent approximations for heavy elements such as gold. In spite of its limitations, therefore, Sommerfeld's classical theory has been used to calculate the positions of the intensity maximum in the angular distribution curves (last column, Table III). Actually the angular position of the hardest radiation (minimum in Fig. 12) is in better agreement with Sommerfeld's predicted angle than is the position of the intensity maximum. In general, theory predicts that the maximum will move toward smaller angles and will become more pronounced as the voltage is increased, but that for a given voltage the harder components of the radiation will have their maxima at larger angles. In these respects theory and experiment are in qualitative agreement.

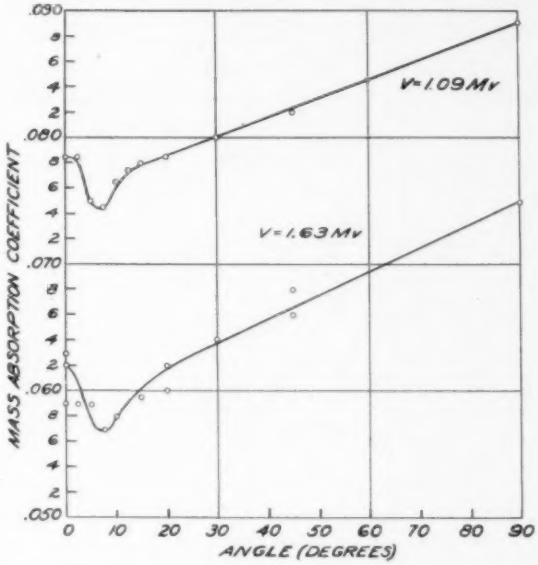

Fig. 13. Dependence on angle of the final value of the mass absorption coefficient in lead for the radiation produced at 1.09 and 1.63 mv.

V. Efficiency of Roentgen-Ray Production

In all the measurements described previously the results have not depended on the absolute calibration of the thimble chamber, and not sensitively upon the variation of this calibration with roentgen-ray quality. The results presented in Figure 14, however, depend on the carbon thimble chamber for the absolute measurement of intensity in roentgens. The roentgen-ray intensity in the forward direction is plotted on double logarithmic paper as a function of voltage for the unfiltered radiation (except for about 2.3 mm. lead equivalent thickness introduced by the target) and for radiation filtered through 2.5 cm. of lead. The unfiltered radiation increases approximately as the third power of the tube voltage or, more accurately, as a power which

[16] Sommerfeld, A. *Phys. Ztschr.*, 1919, *10*, 969.
[17] Sommerfeld, A. *Ann. d. Phys.*, 1931, *11*, 257.
[18] Heitler, W., and Sauter, F. *Nature*, 1933, *132*, 892; Sauter, F. *Ann. d. Phys.*, 1934, *20*, 404.

varies from 2.5 at 0.75 mv. to 3.5 at 2.5 mv. The filtered radiation shows a more uniform increase as the 4.7 power of the voltage. This emphasizes the importance of having high voltage for producing radiation which is to be used through considerable absorbing material.

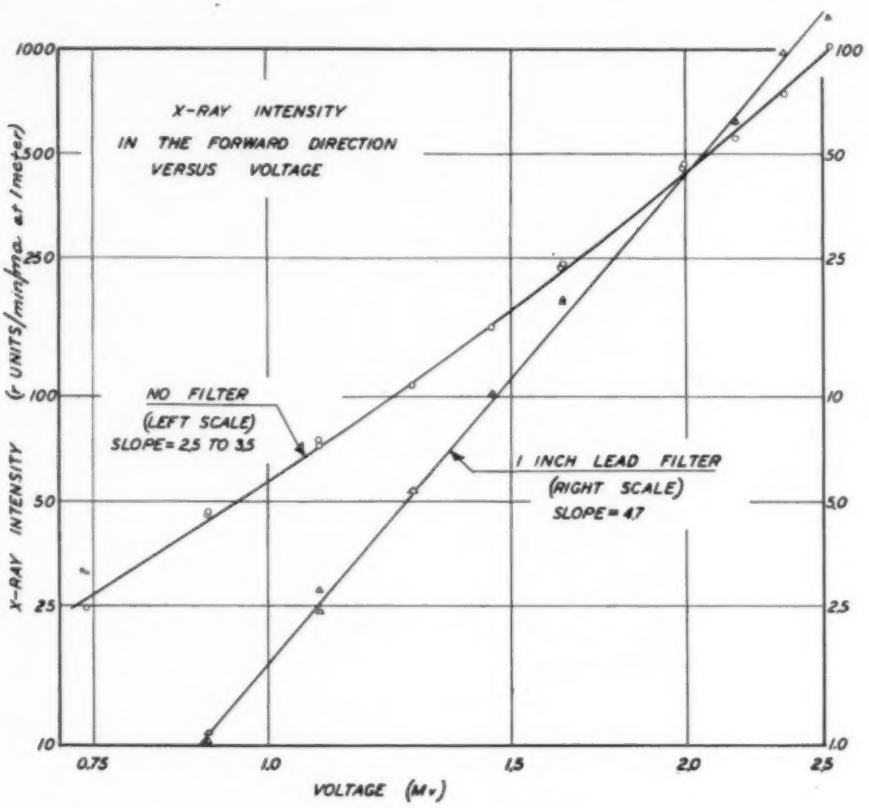

FIG. 14. Dependence of absolute intensity in the forward direction on voltage for unfiltered and filtered radiation.

From a consideration of the roentgen-ray intensity available at high voltage and the low value of the absorption coefficient after moderate filtration, it is evident that roentgenographic examination of very thick specimens, such as heavy steel castings, becomes feasible. If the target-to-specimen distance is made large, sufficient pre-filter is used, and stray radiation is carefully eliminated, good resolution should be obtained for thickness as great as 12 inches of steel.

The efficiency of roentgen-ray production may be defined as the ratio of the power radiated from the target as roentgen rays to the power received at the target as the result of electron bombardment. The power radiated at a given tube voltage and beam current can be determined from a knowledge of the roentgen-ray intensity (in roentgens) in all directions from the target, provided that the proper correction be made for true absorption in the target. Experimental results already presented include the intensity in the forward direction, I_f, measured as a function of tube voltage (Fig. 14) and the relative intensity, I_θ, measured as a function of angle for several tube voltages without filtration (dashed curves of Fig. 10).

The power passing through unit area[19]

[19] The power passing through unit area is the most common meaning of "intensity" in physics, but it has proved more con-

at a distance r from the target and at an angle θ with respect to the forward direction of the beam is given in terms of the reading $I_{r,\theta}$) of an air-wall thimble chamber at that point by

$$P_{r,\theta}=\int_r^\infty Idr=I_{r,\theta}/\mu \text{ roentgen cm/min.}$$

where μ is the linear coefficient for true absorption in air of the heterogeneous radiation incident upon the thimble chamber. If we accept a value of 45.5 electron volts per ion pair as the energy required for roentgen-ray ionization in air,[20] we may write this expression in terms of a more conventional unit.

$$P_{r,\theta}=2.53\times10^{-10}I_{r,\theta}/\mu \text{ watt/cm.}^2$$

The total power passing through a sphere of radius r is

$$P_r=1.59\times10^{-9}r^2\int_0^\pi (I_{r,\theta}/\mu)\sin\theta d\theta \text{ watt.}$$

If we introduce I_f, the intensity in the forward direction expressed in roentgens per minute and milliampere at 1 meter from the target and I_θ, the intensity at angle θ relative to that in the forward direction, and if we recognize the fact that the coefficient for true absorption in air does not depend appreciably on angle,[21] we may write

$$P_1=1.59\times10^{-5}(I_f/\mu)\int_0^\pi I_\theta \sin\theta d\theta \text{ watt/ma.}$$

Then the efficiency of x-ray production is

$$\eta=1.59\,(I_f/\mu V)\int_0^\pi I_\theta \sin\theta d\theta \text{ per cent}$$

where V is the tube drop in volts.

venient here to let intensity refer to the reading of an air-wall thimble chamber.

[20] The generally accepted value of 32 electron volts per ion pair is apparently based on H. Geiger's early value of 33 electron volts obtained from alpha particle ionization experiments (*Proc. Roy. Soc.*, 1909, A *82*, 486). The value of 45.5 ± 1.0 electron volts obtained from the excellent work of J. F. Lehmann and T. H. Osgood on ionization in air by electrons in the energy range 200 to 1,000 e'ectron volts (*Proc. Roy. Soc.*, 1927, A *115*, 609) more properly applies to the case of roentgen-ray ionization. We are indebted to Dr. M. S. Livingston, who brought these references to our attention as well as his own confirming calculation based on ionization by radium gamma rays.

[21] The *total* absorption coefficient in *lead* (Fig. 13) is enormously more sensitive to angle than the true absorption coefficient in air, as can be judged from the dependence on voltage of the corresponding coefficients for homogeneous radiation.

Experimental data already presented make it possible to calculate the efficiency at three voltages: 2.35, 1.63, and 0.90 mv. Values of I_f are obtained from Figure 14 and values of the integral are calculated from the dashed curves of Figure 10. The values of μ, the linear coefficient for true absorption in air of the heterogeneous radiation incident upon the thimble chamber,

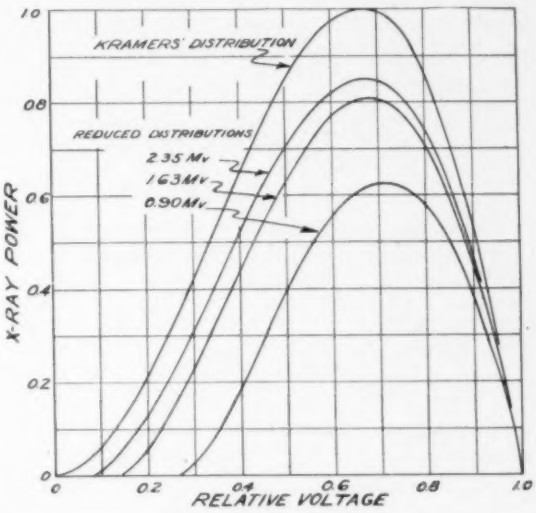

Fig. 15. Distribution in energy of the radiation produced at the target (assumed to follow Kramers' law) and of the radiation after passage through the target for several tube voltages.

were calculated from the corresponding coefficients for homogeneous radiation as the weighted average of these coefficients over the proper curves of Figure 15. The reliability of this method of calculation is indicated by the comparison of results in Table 11. The curves of Figure 15 were obtained by reducing the Kramers' distribution according to the effective thickness of the target and the linear coefficients for true absorption in the several target materials of homogeneous radiation at the corresponding voltages. All the coefficients for homogeneous radiation were obtained from curves calculated from the expressions given for σ, τ, and κ, as were the curves shown in Figure 8. The effective thicknesses of gold, water, and copper in the target were calculated from the target

geometry (Fig. 4) and the angular distribution of the radiation at each voltage (Fig. 10).

From the curves of Figure 15 it is possible also to obtain directly factors to correct for true absorption of roentgen-ray power in the target. The ratio of the area under the Kramers' distribution to that under the reduced distribution gives the factor by which the measured power must be increased to correct for absorption in the target. The correction is not serious except at the lowest voltage. Values of I_f, the integral, μ, the correction factor, and η are presented in Table IV.

TABLE IV

EFFICIENCY OF ROENTGEN-RAY PRODUCTION: A COMPARISON OF EXPERIMENT WITH THEORY

	Experiment				Theory	
Voltage (mv.)	I_f	$\int_0^\pi I_\theta \sin\theta d\theta$	μ	Target Correction Factor	η	η
2.35	750	0.52	3.08×10^{-5}	1.22	10.4	8.3
1.63	240	0.61	3.30	1.35	5.8	5.6
0.90	44	0.68	3.48	2.00	3.0	3.4

The theoretical values for the efficiency given in the last column were computed from curves calculated from Bethe and Heitler's theory by Arcimovic and Chramov.[22] In view of limitations in the theory when applied to targets of high atomic number and the limitations in the measurement imposed by the target correction, the agreement between theory and experiment throughout this voltage range may be considered quite satisfactory.

[22] Arcimovic, L. A., and Chramov, V. A. *Compt. rend. sc.*, U.S.S.R., 1938, *18*, 415.

SUMMARY

In the voltage range from 0.7 to 2.5 megavolts the intensity and the total mass absorption coefficient of the heterogeneous radiation produced in a thick gold target have been measured as a function of tube voltage, angle with respect to the electron beam, and thickness and material of the filter. Curves giving the dependence of absorption coefficient on voltage are presented for lead, tin, copper, aluminum, carbon, and water as absorbers. A method is described for calculating the absorption coefficient of the heterogeneous radiation produced at a given tube voltage and subjected to a given amount of filtration. The accepted values for the absorption coefficient of homogeneous radiation are used. Measured and calculated values of the absorption coefficients for heterogeneous radiation are in good agreement. Curves giving the dependence of intensity on angle are in qualitative agreement with approximate theory. Curves giving the dependence of absorption coefficient on angle and the dependence of intensity in the forward direction on voltage are presented. A method for calculating the efficiency of roentgen-ray production from these data is described and used to obtain results in satisfactory agreement with theory in the voltage range from 0.90 to 2.35 megavolts.

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EDITORIALS

ROENTGENOLOGIC DETERMINATION OF THE HEART SIZE AND PULMONARY FINDINGS DURING ACUTE CORONARY THROMBOSIS

WHETHER coronary thrombosis is on the increase or whether the apparent increase is due to the more frequent diagnosis is a matter of some discussion and the literature on the incidence of cardiac enlargement and the associated pulmonary congestion during and following coronary thrombosis has been determined chiefly from autopsy material. It is true that some roentgen studies have been made but, as Massie and Miller[1] have pointed out, the infrequency of the roentgenograms taken in the various series has not permitted definite conclusions as to the presence or absence of cardiac enlargement in the days immediately following the coronary accident. It is true that case reports have been published concerning this aspect but apparently no report until the present one of Massie and Miller has been made in which a series of successive roentgenograms of the heart were taken to discern the change in cardiac size which might occur in the days or weeks following the myocardial infarction.

On account of the gravity of the condition of the patients the observers exercised great care in the handling of the patients and they are happy to record that no untoward occurrences were encountered in any of them as a result of the study. The patients were permitted to sit on the side of the bed or stretcher and the roentgen tube was placed 5 feet away from the patient, the film holder was kept in contact with the anterior surface of the chest, and the roentgenogram was taken during a phase of quiet respiration.

The method of measurements of the heart size employed in the investigation was the cardiothoracic ratio which is the ratio of the transverse diameter of the heart shadow to the internal diameter of the chest. They used this method of study, admitting that it is only fairly reliable as an index of cardiac enlargement but it is a simple and useful measure of heart size and is the one most often employed.

The complete study was made on 16 patients and each patient had had an attack of undoubted acute myocardial infarction twelve to sixty hours prior to entering the hospital. Within twenty-four hours of the acute episode the initial roentgenogram was taken, and subsequent roentgenograms were taken on the third, fifth, twelfth and twenty-eighth day where such an examination was possible, and then additional studies were made at the end of the third and sixth month after the coronary accident.

In an analysis of their cases it was decided that a total change of less than 1 cm. in the transverse diameter of the heart could be considered within the limit of roentgen-ray error in such a study. They took into consideration the possibility that a change of less than 1 cm. when accompanied by a change of shape of the heart silhouette might be of considerable significance but they did not observe a distinct change in shape in this series of cases. They paid particular attention to the appearance of the lung fields in the successive roentgenograms as a means of

[1] Massie, Edward, and Miller, Wallace C. The heart size and pulmonary findings during acute coronary thrombosis. *Am. J. M. Sc.*, Sept., 1943, *206*, 353–360.

determining the extent of pulmonary congestion in patients with acute coronary occlusion.

From an analysis of the study of 16 patients the authors concluded that there was no consistent change in cardiac size or shape. Half of the patients showed no change at any time during the course of the roentgen study and it was found impossible to determine that there was any significant feature which characterized the 8 patients who showed a change in cardiac size following coronary thrombosis. However, it was discovered that the patients with significant change in cardiac size were more ill than the others. It was significant that 12 of the 16 patients showed roentgenologic evidence of pulmonary involvement, whereas in only 7 of these did auscultation reveal the presence of basal râles.

This report would seem to prove that if a patient with coronary thrombosis is handled carefully there is no risk added by the roentgenologic examination of the chest which often results in considerably more information than is obtained from clinical methods alone.

Underwood & Underwood, Washington, D.C.

WRIGHT CLARKSON
1889-1943

WRIGHT CLARKSON died on October 17, 1943, of lymphatic leukemia. This news brings sorrow to a host of patients, colleagues, and friends.

The demonstrations established years ago by the late Dr. Joseph C. Bloodgood on bone pathology were the forerunner of the American Association for the Study of Neoplastic Diseases, at the meetings of which I came to know Wright Clarkson as one who embodied a highly developed clinical sense, an active inquiring mind, and all the fine traditions of the southern gentleman. I have partaken of the Clarksons' hospitality at the fabulous open house they maintained following the annual meeting

of the Southside Medical Society in December. These obituary notes are written by one who is deeply moved at his death, and who mourns a prized friend.

Dr. Clarkson was born in Center Cross, Virginia, on December 9, 1889. He attended Randolph-Macon Academy, and received his M.D. degree from the Medical College of Virginia in 1912. He practiced in Hardy, Kentucky, from 1913 to 1915, and in Mt. Solon, Virginia, from 1915 to 1918. He was a Lieutenant in the Army Medical Corps in the first world war, and was a graduate of the Army Medical School in 1918. In 1920 he was radiologist of Army Hospital 41, Staten Island, New York, after which he became radiologist of the Petersburg Hospital in his native Virginia. He developed a very large practice in Petersburg, and patients came to him from all over the South. His opinion on the diagnosis and treatment of malignant disease was widely sought. His membership in the American Roentgen Ray Society dates from 1928. He was a member also of the Radiological Society of North America, the American Radium Society, and of the American College of Radiology. He served in the House of Delegates of the American Medical Association. He founded the Virginia Radiological Society, the Virginia Cancer Foundation, and the Fourth District Medical Society of Virginia.

He was married on October 28, 1919, to Miss Caroline Robinson Davis. Their son, Julian Wright Clarkson, is a medical student at the University of Virginia. In addition to his wife and son, his parents and five sisters survive him.

Ramsay Spillman

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual meeting: To be announced.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: 1944, to be announced.

ARKANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Drake Hotel, Chicago, Ill., Executive Sessions only, Dec. 1–2, 1943.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

RADIOLOGICAL SECTION, LOS ANGELES COUNTY MEDICAL ASSOCIATION
Secretary, Dr. Donald R. Laing, 65 North Madison Ave., Pasadena, Calif. Meets on second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N.Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. Warren W. Furey, 6844 S. Oglesby Ave., Chicago, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. D. D. Brannan, 11311 Shaker Blvd., Cleveland 4, Ohio. Meets at 6:30 P.M. at Allerton Hotel on fourth Monday each month, October to April, inclusive.

DALLAS-FORT WORTH ROENTGEN STUDY CLUB
Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meetings held in Dallas on odd months and in Fort Worth on even months, on third Monday, at 7:30 P.M.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Building.

FLORIDA RADIOLOGICAL SOCIETY
Acting Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

RADIOLOGICAL SOCIETY OF KANSAS CITY
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOUISIANA RADIOLOGICAL SOCIETY
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. Annette T. Stenstrom, 1218 Medical Arts Bldg., Minneapolis, Minn. One meeting a year at time of Minnesota State Medical Association.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. Hugh F. Hare, Lahey Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. Ramsay Spillman, 115 East 61st St., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

NORTH DAKOTA RADIOLOGICAL SOCIETY
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

Ohio Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

Philadelphia Roentgen Ray Society
Secretary, Dr. R. P. Barden, University Hospital, Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. R. G. Alley, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Sidney Larson, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

St. Louis Society of Radiologists
Secretary, Dr. P. C. Schnoebelen, 462 N. Taylor Ave. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

Shreveport Radiological Club
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. Herman Klapproth, Sherman, Texas.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. Thomas Carlile, 1115 Terry St., Seattle. Meets fourth Monday each month, October throughMay, College Club, Seattle.

X-ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Medical Members' meeting held monthly on third Friday at 2:30 P.M. and Ordinary Meeting at same time on following Saturday, October to May, 32 Welbeck St., London, W.1.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month at 4:45 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. A. D. Irvine, 540 Tegler Bldg., Edmonton, Alberta.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

South America

Sociedad Argentina de Radiologia
Secretary, Dr. Guido Gotta, Buenos Aires, Argentina. Meetings are held monthly.

Continental Europe

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

WESTERN RESERVE CELEBRATES ONE HUNDREDTH ANNIVERSARY

Western Reserve University School of Medicine, the first medical college founded west of the Allegheny Mountains, celebrated its one hundredth anniversary on October 27, 1943. The Trustees and Faculty invited delegates from many educational institutions, national societies affiliated with the National Research Council, including the American Roentgen Ray Society, Diplomatic Corps, Army and Navy and others of prominence.

The arrangements were made by a committee under the able chairmanship of Professor Howard T. Karsner, Director of the Institute of Pathology. Eminent speakers included Drs. George T. Whipple, Dean of the School of Medicine of Rochester University, Howard T. Karsner, Alan Gregg, Director for Medical Sciences of the Rockefeller Institute and Reginald Fitz, Assistant to the Dean of Harvard Medical School. They presented subjects of scientific and historical interest.

The convocation was one of the most impressive features of the occasion. This began with a colorful procession of over one hundred and fifty of the delegates in academic costumes, preceded by medical students of the Army and Navy, each service bearing and guarding a flag of the United States and this was followed by others in uniform and military formation. Dr. Winfred G. Leutner, President of the University, presided at the ceremonies of the convocation, conferring honorary degrees on five distinguished physicians: Drs. W. T. Corlett, F. C. Waite, Professors Emeritus of the University; Torald H. Sollman, Dean of the School of Medicine, Western Reserve University, G. T. Whipple and Reginald Fitz.

U. V. PORTMANN, *Delegate*

DALLAS-FORT WORTH ROENTGEN STUDY CLUB

The Dallas-Fort Worth Roentgen Study Club, which was organized several months ago, extends an invitation to any radiologist who has the opportunity to attend their meetings. It is felt that there may be a number of radiologists in the Army camps in the surrounding locations who would like to attend these meetings but who are not familiar with the type of meeting nor the time.

The meetings are informal and are held monthly. The group assembles for dinner at seven-thirty and following dinner discussions of general problems and the presentation of interesting roentgenograms are carried out. The meetings are held in Dallas on the odd months of the year and in Fort Worth on the even months, on the third Monday of each month. The cover charge for the dinner is paid by each person attending. Information concerning the meetings can be obtained from Dr. X. R. Hyde, Secretary, Medical Arts Building, Fort Worth, Texas, or from Dr. J. R. Maxfield, Jr., President, Medical Arts Building, Dallas, Texas.

WAR PRODUCTION BOARD AMENDS LIMITATION ORDER L-206

Controls over the manufacture and distribution of X-ray equipment are relaxed by the War Production Board through issuance today [November 29, 1943] of L-206 as amended. Former controls established by L-206, originally issued in October, 1942, were necessary to break the bottleneck in filling military orders. In general, military orders are now being filled on schedule.

Today's amended order, a complete revision of the former order, is designed to provide adequate equipment for civilian use without the paper work formerly required by special authorization of civilian purchase orders and by the filing of production and shipping schedules.

Chief provisions of the amended order are:

Shipments of medical X-ray equipment for civilian use are placed on a quota basis.

Annual shipments of each manufacturer are limited to 75 per cent by dollar value of the average annual shipments made during 1937, 1938 and 1939. Quotas apply only to shipments within the United States, to its possessions and territories, and to Canada.

Medical X-ray equipment for the U. S. and Canadian military services and for export under Lend-Lease and OEW (now part of the Foreign Economic Administration) is not included in the quota. Industrial X-ray equipment is also outside the quota.

Former restrictions on models and types of specified X-ray equipment are removed from the order through deletion of Schedule A.

Monthly reports of shipments by dollar value are required; they are to be made by letter. Production and shipping schedules (Form PD-774) and authorization applications (Form PD-556) need no longer be filed.

Coverage of the order remains unchanged. X-ray equipment, as defined, includes only power units; radiographic, fluoroscopic and therapy tables; photofluorographic units; cassette changers; and tube stands. It does not include parts, accessories or appliances; or rebuilt and second-hand equipment.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

GENITOURINARY SYSTEM

Braasch, W. F., and Doss, A. K. The clinical value of the delayed urogram. *J. Urol.*, April, 1940, *43*, 617–622.

According to the authors, a delayed urogram is a film exposed ten or fifteen minutes after the renal pelvis has been filled with an opaque medium and the ureteral catheter withdrawn. They consider that the emptying time of the normal renal pelvis may vary from three to eight minutes. They consider a delay of ten minutes as indicating stasis and a delay of fifteen or twenty minutes as indicating inadequate drainage. The following factors influence pelvic drainage: fluid intake, posture, recent ureteral catheterization, overdistention of the ureter, obstruction of the lower urinary tract, reflex delay following operations on the kidney and ureter, stone or infection, and disturbances of innervation.

Delay in emptying is of more significance if the patient is kept in the erect posture. Normal drainage does not exclude a previous obstruction. The medium used should not be too irritating since this factor would promote rapid emptying. It is important to distinguish between dynamic and adynamic stasis since the former is usually amenable to surgery and the latter not. Adynamic stasis usually does not cause pain unless secondary obstruction occurs. The delayed urogram is also of value in determining the advisability of nephropexy in nephroptosis since this procedure is only advised in cases of obstructed renal drainage.—*R. M. Harvey.*

Weyrauch, Henry M., Jr. Death from air embolism following perirenal insufflation. *J. Am. M. Ass.*, Feb. 24, 1940, *114*, 652–653.

Air embolism is a potential danger whenever air is injected into any organ or tissue of the body. The increasing popularity of perirenal insufflation as an aid in the diagnosis of tumors of the retroperitoneum makes pertinent a note of warning concerning the method. If utilized at all, this diagnostic aid should be reserved for that small group of patients for whom the observations made by its use may prove of extraordinary value. Care should be exercised to avoid traumatization of the surface of the kidney and the tissues injected, and the injection should be carried out under as low a pressure as possible. It has been recommended by others that air be injected at a pressure not exceeding 30 mm. of mercury, but this is 15 mm. greater than the pressure in the venules and 25 mm. higher than that in the larger veins.

The author cites a case of a white woman, aged thirty-eight, with a smooth, extremely hard mass in the abdomen. Retrograde pyelograms revealed the right kidney displaced downward and medially. Injection into the right perirenal space of 200 cc. of filtered air was made. A manometer was not used to check the pressure employed in the injection, but no excessive force was exerted. The patient became unconscious two or three minutes after the injection, later revived slightly, but died twenty-one hours after the perirenal insufflation. At autopsy microscopic sections of the brain, lungs and kidneys showed antemortem clots obstructing many of the smaller arteries, veins and capillaries. The primary tumor was found to be an adenocarcinoma of the cecum. The liver was tremendously enlarged due to metastasis, and it was this which displaced the right kidney downward and medially.—*S. G. Henderson.*

Morgan, J. B. Pneumopyelography. *J. Urol.*, May, 1940, *43*, 669–671.

Pneumopyelography was first suggested by Lichtenberg in 1911. It was later abandoned because of fear of air embolism, which could be produced experimentally. Later experimental work on dogs by Bedrna revived interest in the procedure and indicated the lack of danger if excessive pressure was not employed and only about 10 cc. of air injected. Many European clinics are using this procedure as a routine and according to the author no accident has ever been reported. It has not been adopted in America.

The author has done over 200 pneumopyelograms in three years without complications oc-

curring. Occasional mild colic during the injection has been observed. He feels the method is of especial value in demonstrating non-opaque calculi, early papillomata, ureteral stricture, and incrustations within a tumor or the renal pelvis. He feels that there is no contraindication to pneumopyelography which is not a contraindication to pyelography with an opaque medium.—*R. M. Harvey.*

ROENTGEN AND RADIUM THERAPY

O'BRIEN, M. G. Primary sarcoma of the epididymis; case report. *J. Urol.*, March, 1942, *47*, 311–319.

A review of the literature reveals 91 reported cases of malignant tumors of the epididymis of which 7 were fibrosarcomas. The author reports a case in a male, aged twenty, who complained of a swollen and painful left testicle. The swelling followed a severe blow. On physical examination, an indurated mass, the size of an orange in which testicle and epididymis could not be distinguished, was present in the left scrotal sac.

Pathological examination after orchidectomy showed a fibrosarcoma originating in the epididymis. At the time of his discharge there was no evidence of metastasis. Deep roentgen therapy, 1,400 r, was given to the left loin. Six weeks later roentgenograms of the chest showed metastasis to three ribs but clear lung fields. Nine days later there were multiple metastatic lesions of all bones except the arm below the elbow and the legs below the knee. This rapid widespread metastasis is rare in these tumors.—*R. M. Harvey.*

BARRINGER, B. S. Prostatic carcinoma. *J. Urol.*, March, 1942, *47*, 306–310.

The author reviewed 352 consecutive cases of prostatic cancer which had been treated in the fifteen year period from 1922 to 1936. The general principles of treatment have been radiation therapy with minimal operative intervention. The percentage of cures has not improved in the fifteen year period. Ten per cent of cases survived five years, and one-half of these died of cancer between five and ten years. Four of 21 controlled cases had suprapubic prostatectomy with irradiation for recurrences.

Two surviving and controlled cases were treated only with implanted gold seeds. One patient was treated solely with deep roentgen therapy, 3,600 r×4 at 70 cm. Most of the 21 controlled cases had radon needle implantations in the prostatic and periprostatic regions. The needles were inserted through the perineum and were removed at the expiration of treatment.

The author feels that irradiation helps to maintain the patency of the prostatic urethra regardless of its curative value. If castration by roentgen therapy is to be done for its effect upon pain, bone metastases, and the general well-being of the patient, at least 1,500 r should be administered. (It is not stated in the article whether this dose is in air, on the skin, or delivered to the testicles.)—*R. M. Harvey.*

BAILEY, WILBUR, and KISKADDEN, WILLIAM S. Treatment of hemangiomata, with special reference to unsatisfactory results. *Radiology*, May, 1942, *38*, 552-561.

Vascular angiomata should be treated early for though they occasionally show spontaneous retrogression they are much more apt to progress if not treated promptly. Failure in these cases often results from failure to consider the type of hemangioma under consideration and to adapt the treatment to it. In capillary hemangiomata or port wine stains the lining of the capillaries is a differentiated adult endothelium which is very radioresistant and therefore radiation therapy is not advisable in these cases. The preferred treatment is surgery or cosmetic pastes.

In hypertrophic endothelial hemangiomata or strawberry marks and in deep cavernous hemangiomata irradiation is of value. Roentgen rays are less satisfactory than radium, particularly in small children. The author advocates the use of filtered radium packs at a distance of 3 mm. for superficial lesions and 1 to 3 cm. for deeper lesions. The radium must be arranged so that all parts of the tumor are irradiated as evenly as possible. A filter of 0.5 mm. platinum stops all beta radiation and in addition to this secondary filters of 1 mm. silver and 0.5 mm. brass are used. He has never seen any injury from the use of radium packs properly filtered. The use of the beta radiation from unfiltered packs may injure the skin. Carbon dioxide snow is useful for small superficial hemangiomata but should not be used for the deep forms. The im-

plantation of radon seeds is a valuable method for patients who live at a distance as it frequently requires only one visit.

In the discussion Dr. Stevens said that in his opinion too much stress had been laid on the direct action of radiation on the endothelial cells, overlooking the effect of the rays on the stroma. He has never had bad effects from the use of radium.

Dr. Bailey replied that one of his reasons for writing this paper was the unsatisfactory results that had been seen from the use of radium plaque beta-ray therapy. Probably this was due to the use of the method by physicians who were not radiologists so that skin damage had resulted. Also the deeper parts of the hemangiomata had not been affected because of neglect to determine the depth dose.—*Audrey G. Morgan.*

Borak, J. Radiation effects on the blood vessels. Part II. Inflammation; degeneration; suppression of growth capacity; retrogression, necrosis. *Radiology*, May, 1942, *38*, 607–617.

When the dose of radiation is increased edema and hyperemia are followed by inflammation. This differs from inflammation of bacterial origin in that lymphocytes appear first and then polymorphonuclear leukocytes, as the inflammation is aseptic and there are no free substances to attract the leukocytes.

A detailed description is then given of the later steps in the process: coagulation, vacuolization, degeneration, suppression of the capacity for growth, retrogression and necrosis. There is a form of radionecrosis which begins in the arteriovenous anastomoses below the subpapillary plexus and another which begins in the terminal arterioles above the subpapillary plexus. The former is associated with ulceration, the latter with moist radioepidermitis with destruction of the epidermis (epidermiolysis) and inflammation of the underlying derma. The first type is caused by a large dose given all at once and the second by fractional irradiation; consequently the latter is milder than the former. After epidermiolysis the epidermis is replaced from the surrounding epidermis, while the other form of radionecrosis seems to be permanent. The subpapillary plexus is evidently unable to produce new capillaries.—*Audrey G. Morgan.*

Borak, J. Radiation effects on the blood vessels. Part III. Telangiectasis; effects on lymph vessels. *Radiology*, June, 1942, *38*, 718–727.

Telangiectasis is a dilatation of the capillaries in which the capillaries become as large as veins. These capillaries do not react to histamine because they have reached the limit of dilatation. While erythema develops within a few hours or days after irradiation telangiectasis does not develop in most cases for about a year. Telangiectasis is usually considered an indication of severe damage to the vessels and a forerunner of tissue necrosis. The changes are in the veins rather than in the arteries.

Telangiectasis may be caused by a total dose of as little as 2,400 r if the individual doses are 400 r, while it does not develop with doses of 4,800 r or more if the individual doses are 100, 200 or 300 r, as these doses lie below the level necessary to cause edema and consequent fibrosis of the veins. Doses which in themselves will not cause telangiectasis will have this effect if pressure is exerted on the tissues. On the contrary, edema and erythema are more intensive in the absence of compression.

While arteriofibrosis caused by irradiation is serious and constitutes a contraindication to further irradiation this is not true of fibrosis of the veins which is chiefly of cosmetic importance, if any.

The changes in the lymph vessels caused by irradiation are discussed. It seems that normal lymphatic capillaries may be narrowed by large doses while dilated lymphatic capillaries may be narrowed by small doses. Apparently primary dilatation of normal lymphatic capillaries cannot be brought about by irradiation. Tissues in a condition of inflammatory edema are hyperemic and therefore their radiosensitiveness is increased while those in a condition of generalized edema are anemic and their radiosensitiveness is decreased.—*Audrey G. Morgan.*

Bethell, Frank H. Lymphogenous (lymphatic) leukemia; diagnostic, prognostic and therapeutic considerations based on analysis of its morphologic and clinical variants. *J. Am. M. Ass.*, Jan. 10, 1942, *118*, 95–99.

Lymphogenous leukemia comprises a group of pathologic states which have as their common attribute disordered and continued proliferation of lymphocyte-forming tissue not

limited in response to any recognized irritant or other stimulus and manifested by continuous or intermittent alteration in the lymphocytes of the circulating blood. It is possible to classify patients with lymphogenous leukemia into three main groups on the basis of the type of lymph cell concerned in the process: the lymphoblast, the lymphosarcoma cell and the lymphocyte. The material of this study comprises 190 patients with lymphogenous leukemia observed from 1928 to 1940, inclusive. There were in this series 52 cases of lymphoblastic, 70 of lymphosarcoma cell and 68 of lymphocytic leukemia.

Lymphoblastic leukemia is a cataclysmic disaster of childhood, occurring in the majority of cases in the first decade of life and beginning and terminating in 90 per cent before the age of twenty. Two-thirds of the patients in this series were male. Lymphosarcoma cell leukemia is characterized by the presence of lymphosarcoma cells in the blood stream. It may occur at any age and affects males predominantly. Lymphocytic leukemia was found almost exclusively in the middle and later years of life in this group of patients. Both in lymphocytic and lymphosarcoma cell leukemia women were affected earlier than men, but males were affected most often in both forms of disease.

The most common early manifestations of lymphoblastic leukemia were lassitude, ease of fatigue and weakness, symptoms generally referable to anemia. With both lymphosarcoma cell and lymphocytic leukemia the most common first sign of disease was enlargement of peripheral lymph nodes or the spleen, usually of the former.

Death occurred within four months in 70 per cent of the cases of lymphoblastic leukemia. Nearly one-half the patients with lymphosarcoma cell leukemia died within one year of the onset of symptoms or the observation of a tumor. The duration of life in lymphocytic leukemia averaged 4.85 years. The greatest hazard to life in this form of disease is the susceptibility to infection, particularly pneumonia.

The author found that radiation therapy was apt to adversely affect the course of the illness in lymphoblastic leukemia. In lymphocytic leukemia roentgen therapy proved of much greater value than the use of arsenicals or any other form of treatment employed. The usual procedure involved the use of 200 kv., and a dose per treatment of 150 to 200 r, measured in air, to fields ranging from 10 by 10 cm. to 15 by 15 cm. A series of daily treatments numbering usually eight to twelve was applied regionally to the peripheral lymph node areas, the mediastinum, the retroperitoneal region and the spleen. The indications for therapy are anemia, debility, evidence of increased metabolism, pressure symptoms, and a progressive rise in the leukocyte count. In patients with lymphosarcoma cell leukemia localized therapy directed only toward the relief of pressure manifestations is often advisable. Some derive prolonged benefit from roentgen therapy to all of the major regions of lymphatic tissue.—*S. G. Henderson.*

SANDLER, BERNARD. The effect of bone absorption on delivered x radiation and its relation to pre-determined pelvic dosage schemes. *Brit. J. Radiol.*, Jan., 1942, *15*, 20–23.

In treating cancer of the cervix not only must the cancer be irradiated but also the sites that may be invaded. In using combined roentgen and radium treatment the complementary dosage of the two kinds of radiation must be very accurately dove-tailed or else there will be underdosage or overdosage at some point. In calculating dosage heretofore not enough allowance has been made for bone absorption. In order to compute the values for bone absorption a wax model was made of an actual female pelvis and a disarticulated female pelvis inserted in it. A mixture of beeswax, paraffin and resin was then prepared which was equivalent in its properties to human soft tissue and the cast was filled with this mixture. Holes were bored in the wax for the insertion of a measuring chamber. In measurements on this model the factors of back-scatter and absorption are approximately what they would be in actual treatment. A table of dosage measurements is given which shows that the effect of bone absorption is considerable in the posterior fields.

The work shows the importance of more extensive studies of the effect of bone on the absorption and scattering of radiation.—*Audrey G. Morgan.*

TUTA, JOSEPH A., and ROSI, PETER A. Lymphosarcoma of the rectum. *Arch. Surg.*, Jan., 1942, *44*, 157–163.

Lymphosarcoma of the rectum is rarely recognized until histopathological examination has been made, and even then it is sometimes

difficult to exclude inflammatory processes and benign lymphoid tumors.

A case is described in a man of twenty-seven who complained of a mass which sometimes protruded from the anus. Proctoscopic examination showed a polypoid mass in the right posterior quadrant of the anus. This was removed and histopathological examination showed evidence of malignancy. Photomicrographs are given of the large islands of lymphoid tissue surrounded by varying amounts of connective tissue, with extension of the lymphoid infiltration into the mucosa, causing ulceration and bleeding.

The tumor was excised into normal tissue and as it was not of an extremely malignant type this may save the life of the patient. He has had no recurrence seven months after operation, but lymphoid involvement of other parts of the gastrointestinal tract may occur years later. Local wide resection of the tumor should as a rule be followed by irradiation of the region.—*Audrey G. Morgan.*

Vanzant, B. T. Roentgen therapy in hereditary diffuse polyposis of the colon. *J. Am. M. Ass.*, March 14, 1942, *118*, 875–878.

Diffuse polyposis of the colon of the hereditary type is a distinct disease entity characterized by the presence of multiple, sessile or pedunculated polyps. Ultimately malignant degeneration almost invariably occurs in one or more polyps.

The onset of symptoms may be noted in infancy but characteristically occurs at about twenty years of age. There is hypermotility of the bowel and diarrhea, mucus in the stools, and frequently blood from ulceration of the surface of the growths. Because of the mildness of the early symptoms the patient is not likely to present himself for examination and treatment until a number of years have passed. Some of the polyps have already undergone malignant changes at the time of the first consultation in a large percentage of cases.

Medical measures are important in relieving diarrhea, improving nutrition, combating anemia and eradicating associated infections of the bowel. The simplest surgical measure employed is fulguration,—applicable only to rectal and sigmoid lesions. Total colectomy which is frequently advised as a prophylactic measure in the earliest recognizable stage of the disease is a formidable operation and indefensibly radical. Roentgen therapy may prove to be valuable in every phase of the disease. As is well known, hyperplasia of lymphatic tissues and lymphatic infiltrations are peculiarly susceptible to irradiation. Both these conditions are characteristic features of this disease. Even after the lesions have advanced to the stage of mucosal hyperplasia and adenoma formation, the tissues are still radiosensitive because of their accelerated rate of growth and tendency to dedifferentiation. The author reports 2 cases treated with roentgen irradiation. One patient was treated first in 1935 with almost complete disappearance of symptoms. During a period of ten weeks a total of 4,000 roentgens in fractional doses was given over each segment of the abdomen. When diarrhea reappeared in 1938 he was again given roentgen therapy and his health remained good until 1940, when, after a recurrence of symptoms lasting for four months, he died. The second patient had an associated severe amebiasis. In spite of this he was carried along with roentgen treatment for over two years before death ensued. The author concludes that roentgen therapy is a logical and effective adjunct in the treatment of multiple polyposis.—*S. G. Henderson.*

MISCELLANEOUS

Reinhard, M. C., and Goltz, H. L. Comparative isodose charts for 200 kv., 400 kv., and 1,000 kv. x-rays. *Radiology*, Jan., 1942, *38*, 74–76.

The higher voltage roentgen rays have two physical advantages over the lower ones, namely an increase in the percentage depth dose and a decrease in the amount of radiation scattered to the tissues outside the primary beam. The scattered radiation reaches its maximum at 200 kv. with large fields.

For purposes of comparison, isodose curves are given for 200 kv., 400 kv. and 1,000 kv. radiation. The measurements were made with a thimble-type ionization chamber (Victoreen condenser r meter) with typical field sizes—5×5, 10×10 and 20×20 cm.—at a distance of 70 cm. By measuring the intensity of the central ray at the surface and at various depths and also at numerous points lateral to the central ray at the same depths, data were obtained for the complete isodose curves that are shown. Data are also given in regard to the relative volume of tissue irradiated outside of the beam for the various voltages and field sizes.—*Audrey G. Morgan.*

WARNER, A. H., and NEIL, R. H. Stepless voltage controls for x-ray generators. *Radiology*, Jan., 1942, *38*, 77–79.

A new type of autotransformer with sufficient power-handling capacity for therapeutic use has recently been placed on the market by the General Radio Corporation of Cambridge, Massachusetts under the name of Variac. This has been added to the installations in use at the Los Angeles Tumor Institute, one a 200 kv. unit and the other a 100 kv. unit. Photographs are given of the installations with the new autotransformer and diagrams of the old method in which the operation of the roentgen tube had to be stopped before any change in voltage could be made and the new method in which a change in voltage can be made while the tube is in operation.—*Audrey G. Morgan.*

DU MESNIL DE ROCHEMONT, R. Die Dosenverteilung bei der Rotationsbestrahlung. VI. Über die Beeinflussung der Oberflächendosis durch den Streustrahlenmantel und durch die Ungleichmässigkeit der Intensität im Strahlenkegelquerschnitt. (The distribution of dosage in rotation irradiation. VI. The effect on the surface dose of the mantle of secondary radiation and the lack of uniform intensity in the cross section of the cone of rays.) *Strahlentherapie*, 1941, *69*, 407–416.

The good depth effect of rotation irradiation is due to the difference between the exposure time of the deep focus and that of the skin surface. In calculating the surface dosage it is necessary to take into account the lack of uniformity in intensity within the bundle of rays and the mantle of secondary radiation around the primary cone of rays. In order to do this, it is necessary to calculate, instead of the actual breadth of skin on which the primary bundle acts, what is called an "effective width of field," which takes these factors into account. The method of making the calculation is described and a graph given showing the percentage surface irradiation for various distances calculated in this way.

As a general rule, the difference between the actual breadth of the ray bundle and the effective width of field increases with the size of the field. For small fields it is between 1 and 2 cm. and for larger ones between 3 and 4 cm. With small body diameters and large fields it is necessary to count also a secondary radiation from the side of the body turned away from the tube.—*Audrey G. Morgan.*

DICKINSON, J. C. What obligations do we have to the radiologist who is called into the national service? *Radiology*, May, 1942, *38*, 584–589.

This article outlines plans for safeguarding the practice of radiologists called into the national services and for seeing that the public gets as good radiological service as is possible under the circumstances. Men who are physically fit should be encouraged to enter the services and in order that they may be able to do so they must be assured that their colleagues at home will cooperate and that their practice will not be lost while they are gone. A locum tenens might take over the practice of a radiologist and carry on the work in the name of the absent one, making reports in his name and thus keeping it before the public and the income from the practice should be shared on an equitable basis so that too great financial sacrifice will not be required from either. As to institutional work, hospitals should be encouraged to promise radiologists their positions when they return from service and if the volunteer desires it he should be allowed to select his temporary successor, subject of course to the approval of the hospital. The American College of Radiology will call on the state and local societies in helping to work out detailed plans for protecting the interests of all concerned.—*Audrey G. Morgan.*

KIRKLIN, B. R. Maintaining the supply of specialists during the national emergency. *Radiology*, May, 1942, *38*, 599–601.

The author, who is Secretary of the American Board of Radiology, urges the importance of allowing a certain number of promising students of radiology to continue their training as specialists. Formerly draft boards allowed certain promising students to complete a three year graduate course in their specialty. Now it is understood that graduates in medicine are to be called into active service as soon as a year's internship is finished. If this plan is continued the ranks of the specialists will be depleted rapidly.

The author urges a two year specialist course in which special attention will be paid to the needs of military radiology. Enough students should be allowed to take this special course so that an adequate number of specialists trained in medical radiology may be available as long as the emergency lasts.—*Audrey G. Morgan.*

de Lorimier, Alfred A. Requirements for roentgenological services in the field of combat. *Radiology*, May, 1942, *38*, 590–598.

The Army needs more roentgenologists than are now qualified and available. Moreover the roentgenologist in the combat zone in addition to his ordinary duties as a roentgenologist must often assume responsibilities usually assumed by the surgeon or internist. In both the surgical hospital and the evacuation hospital quick judgments are required and the roentgenologist must have self reliance and resourcefulness. For an army of 3,600,000 the Army needs approximately 1,000 roentgenologists. Those at present available must be assigned to the best advantage possible, taking into consideration their training and previous experience and others must be trained as quickly as possible, facing the fact that the course must be much shorter than that usually given candidates for a fellowship in roentgenology in a teaching institution.

The Army Medical School is now giving an intensive basic course in roentgenology consisting of a four weeks didactic lecture course and subsequent supervision. The program of the lecture course is given in full.—*Audrey G. Morgan.*

Carey, R. M. Epidermoid carcinoma in the first decade of life. *J. Pediat.*, April, 1942, *20*, 496–498.

Epidermoid carcinoma in the first decade of life is an extreme rarity. The Memorial Hospital in New York reported 14 cases of carcinoma in individuals up to and including ten years of age in a series of over 16,500 cases of malignant tumor. The author reports a case of epidermoid carcinoma on the buccal mucosa of the inner surface of the cheek in an infant aged four months. No adenopathy was present. The growth was removed and no evidence of recurrence was noted ten months later.

Histopathological examination showed an epidermoid carcinoma with typical pearl formation. The tumor was surrounded by mucoid material which was thought to have escaped from an injured buccal gland. This mucoid material was thought to have some possible etiological significance in the production of the tumor.

This is the youngest case reported in the literature of epidermoid carcinoma.—*R. M. Harvey.*

Jacobs, Lewis G. A simple calculator for therapy exposure times. *Radiology*, June, 1942, *38*, 715–717.

A nomograph is described and illustrated which will give the correct exposure time for any dose within its range, 20 to 2,000 r in this case, for various techniques and various focus-skin distances. It requires only a single setting of a sliding scale and the stretching of a string across from the dose scale through the distance scale to the time scale. All the scales are simple logarithmic scales and they must be made parallel and equidistant. Anyone can learn to use the chart with brief instruction. It protects from errors in arithmetic for if the settings are chosen correctly the chart will be accurate.—*Audrey G. Morgan.*

Rendich, Richard A., and Poppel, M. H. The use of a modified opaque meal in gastro-roentgenography. *Radiology*, May, 1942, *38*, 602–606.

A modified opaque meal is recommended which consists of 20 grams of a mixture of four parts barium sulfate, one part gum acacia, one part cocoa and one part granulated sugar by volume added to 7 ounces water and mixed thoroughly.

With the use of this meal it is possible to see most of the outline of the filled stomach and also the rugae of the gastric mucosa on one film. The authors have found it of special value in differentiating between benign and malignant ulcers on the lesser curvature of the stomach. If the ulcer is benign its neck can be seen while in malignant ulcer the meniscus sign is seen. In benign ulcers the rugae can be seen and they may converge; in malignant ulcer the rugae disappear and the mucosa appears granular. In benign ulcer the density of the niche is uniform while in malignant ulcer it may be irregular.—*Audrey G. Morgan.*

Rothenberg, Robert E., and Rosenblatt, Philip. Motility and response of the great omentum. I. Fluoroscopic observations on omental activity of dogs. *Arch. Surg.*, April, 1942, *44*, 764–771.

There has been a great deal of difference of opinion in regard to the activity of the omentum. The authors describe experiments made on dogs in studying this question. Normal conditions were closely simulated in the experiments. Small brain clips and opaque threads were

buried in the omentum and their movements followed roentgenoscopically. They were too light to interfere with the movement of the omentum.

The experiments showed that the omentum of the dog has no active motility. Slight longitudinal excursions are caused by respiration. No change in the position of the omentum is caused by vomiting or defecation. The movements of the great omentum are passive and brought about by the underlying bowel.

In one case the peritoneum was injured by implanting large doses of virulent colon bacilli. Lethal doses did not cause peritonitis but the defense was evidently exercised by the peritoneum. Roentgenoscopic examination did not show any change in the position of the omentum and it evidently did not take any part in the defensive process.—*Audrey G. Morgan.*

STANFORD, BRIAN. A research into the physical factors concerned in indirect radiography. VII. The effect of x rays on the light-transmission of glass. *Brit. J. Radiol.*, Jan., 1942, *15*, 24–26.

In this paper figures are given for the loss of transmission of light from the irradiation with roentgen rays of the glasses used in apparatus for indirect roentgenography. Tables of the figures for crown barium glass and protective lead glass are given and the method of arriving at the figures described. The figures show that lead glass protection should always be used in apparatus designed for indirect roentgenography.—*Audrey G. Morgan.*

GRAY, L. H., and READ, JOHN. The effect of ionizing radiations on the broad bean root. Part I. *Brit. J. Radiol.*, Jan., 1942, *15*, 11–16.

Reference is made to work done in 1939 by the authors in collaboration with W. J. Mottram in which they studied the action of fast neutrons and gamma rays on broad bean roots, grown in darkness to avoid the daily rhythm of mitosis which affects radiosensitiveness. They found that the absorption of a given amount of neutron energy by the cell produced the same effect as the absorption of ten times this amount of gamma-ray energy. There also seemed to be differences in the mortality-dose curves for the two kinds of radiation.

In this series of articles, therefore, they study the mortality-dose curves of broad bean roots irradiated by gamma rays, fast neutron irradiation, alpha particles and roentgen rays. By combining sublethal doses of pairs of radiations they hope to determine the extent to which each type of radiation contributes to the death of the root.

This article is devoted chiefly to a discussion of the details of the method of experiment and the mathematical method of working out their statistical results. They did not detect any definite qualitative difference in the behavior of the roots irradiated with the different types of radiation. The results of the quantitative studies will be given in later papers.—*Audrey G. Morgan.*

LANGMEAD, W. A. A direct-reading instrument for the measurement of ionization currents in gamma-ray therapy. *Brit. J. Radiol.*, Jan., 1942, *15*, 27–32.

The difficulty in constructing direct-reading methods for the measurement of gamma-ray intensity lies in the smallness of the ionization currents to be measured, sometimes as small as 10^{-13} amperes. An instrument is here described and illustrated with which such small currents can be measured. It makes use of the comparatively recent thermionic electrometer. The ionization chamber is cylindrical and made of elektron metal. The difficulty of battery fluctuations is discussed and the method of overcoming them described. The method of calibrating the instrument is also described.

One of its most obvious uses is to determine the isodose curves around radium sources that are irregular geometrically.

The instrument can be adapted easily to the measurement of roentgen-ray intensity. It is only necessary to replace the 10^{10} ohms resistance with one having a lower value appropriate to the ionization currents to be measured. For roentgenological work the elektron metal chamber must be replaced by one more strictly "air-wall" in composition, such, for instance, as carbone.—*Audrey G. Morgan.*

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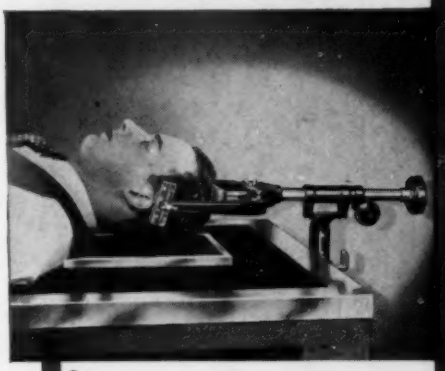

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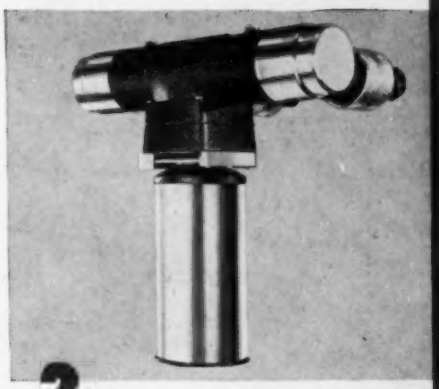

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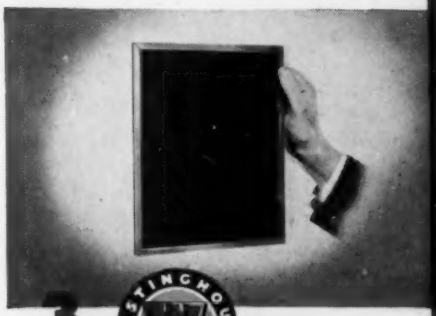

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